MADURAI KAMARAJ UNIVERSITY

(University with Potential for Excellence)

DISTANCE EDUCATION

M.B.A

Second Year

IV - Semester

Elective IV - Production

MATERIALS MANAGEMENT

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MATERIALS MANAGEMENT

MADURAI KAMARAJ UNIVERSITY
MADURAI - 625 021.

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SYLLABUS

MATERIALS MANAGEMENT

Introduction to Integrated Materials Management Organisation for Materials Management, Material Planning. Budgeting, Application of forecasting techniques, exponential.smoothing, Time Series analysis in materials management. Purchase polices, Purchase procedure, Development of source, Import substitution, Vendor rating, Price trends-make or buy decision, Capital equipment purchases, International buying and import procedure, Legal aspects of purchase. DGS & d organization, Policies and procedure, Purchase ethics, Value analysis Codification and standardization.

Introduction to Inventory Control, Inventory Costs, Selective Control (ABC analysis, models – EOQ Model – Modification of EOQ under different conditions, (Price discounts, working capital restrictions, space restrictions, no.of orders restriction). Dynamic inventory models, Q-System, P-Systems, 2 bin system. Concept of safety stock, Determination of safety stock for variation in consumption during lead time, variation in lead time. Determination of service level based on cost optimization. Application of simulation in inventory control. Spare planning and control.

Storage and preservation stores accounting, Verification, valuation, disposal of surplus and scrap material. Performance evaluation of materials management.

Material Sourcing – Vendor Development. Latest Techniques like MRP I & MRP II, JIT Concepts, KANBAN.

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CHAPTER 1

INTRODUCTION TO MATERIALS MANAGEMENT

1.1 Introduction
1.2 Integrated Material Management Organization
1.3 Material Planning
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1.1 INTRODUCTION

The definition of Materials Management accepted by the **International Federation of Purchasing and Material Management** is "Material Management is a total concept involving an organizational structure unifying into a single responsibility, the systematic flow and control of material from identification of the need through customer delivery."

The National Association of Purchasing Management (USA) gave a definition as "Materials management is an organizational concept in which a single manager has authority and responsibility for all activities, principally concerned with the flow of materials into an organization. Activities are purchasing, planning and scheduling, maintaining the incoming and outgoing materials, inventory control, and record maintenance."

Bailey and Farmer define "Materials management is managing the flow of materials into an organization to the point, where, those materials are converted into firm's end products".

Lee and Dobler define "Material Management is a confederacy of traditional materials activities bound by a common idea – idea of an integrated management approach to planning and acquisition, conversion, flow and distribution of production materials from the raw materials stage to the finished product stage"

Materials management serves various functions such as material plan-

ning, scheduling, purchasing, receiving, store keeping, material handling, inventory control, and scrap and surplus disposal. These functions should always yield optimum results for the better working of other departments in an organization. Material management is treated as an important area of management because the cost of materials is a major part of the cost of production. Generally materials department is integrated with every department of an organization and it is considered as a service and supporting agent for the production and financial functions.

The importance of material management lies in a fact that the contribution made by the material manager in reducing material cost will reflect in the pricing of the product, profitability as a rate of return on investment and increasing the sales with the growing competition. They should also concentrate on quality of the materials in huge procurement and maintaining a stock of a material.

In an integrated concept, the materials manager can easily understand his responsibility and monitor all inter-related function involved in the material management. Integration also helps in the rapid transfer of data among departments through effective and informal communication channels. This is a crucial because material management function usually involves more process and more data to maintain for the future aspects. Integration makes to identify the needed requirements with shortened channel and possible to coordinate until fulfilling the requirements.

Objectives of Integrated Material Management

The main objectives of integrated material management are:

- To minimize material cost
- To procure and provide materials of desired quality, when required at the lowest possible overall cost of the concern.
- To purchase, receive, handling and store keeping efficiently and reduce the related costs.
- To trace new sources of supply and to develop cordial relations with them in order to ensure continuous material supply at reasonable rates.
- To cut down costs through simplification, standardization, value analysis, import substitution, etc.
- To modify paper work procedure in order to minimize delays in

procuring materials.

- To conduct studies in areas such as quality, consumption and cost of materials so as to minimize cost of production.
- To train personnel in the field of material management in order to increase operational efficiency.

Purchasing:

Pay low price for the best value obtained

Negotiation

Vendor selection

Right quality at right time

Storage:

Minimizing transportation and handling costs

Adequate and proper storage and preservation of materials

Store as per requirement

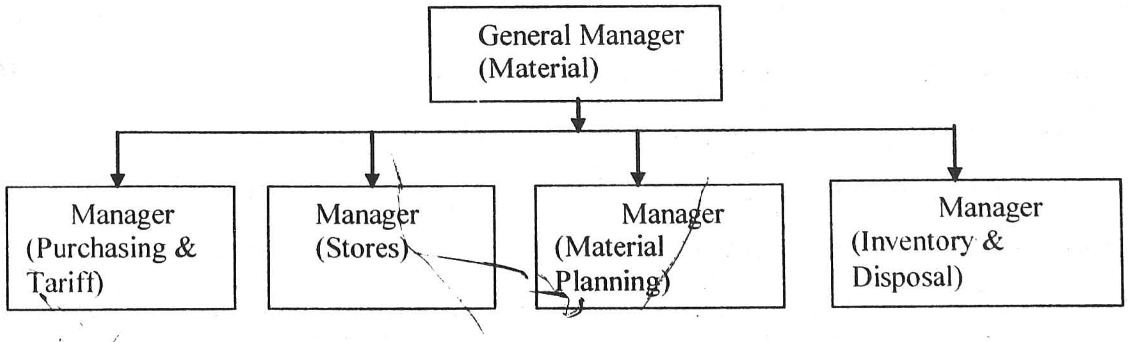
Movement:

Distribution of finished goods to customer

Disposal of raw material

1.2 INTEGRATED MATERIAL MANAGEMENT ORGANIZATION

Material management is related as an important area of management like production, marketing, finance and human resource management. In enterprises where the cost of materials is a major part of the cost of production, material management is not considered as a sub function of production, but considered as equal to production management, but in small or medium scale industries the material management function is considered as a part of production management function. It is considered as a service function or supporting function to production. The organization structure of material management in large scale industries are:



Areas of material management

The material management covers all aspects of material costs, supply and utilization. The responsibility of material manager is given below:

- Material planning and sourcing
- Purchasing
- Stores keeping
- Inventory planning
- Scheduling
- Receiving, warehousing, and transportation
- Value analysis and pre-design value analysis
- Standardization and variety reduction
- Vendor development
- Material handling

Disposal of scrap and surplus various functions served

By materials management include the material planning, purchasing, receiving, stores, inventory control, scrap and surplus disposal. All these functions can have separate working norms including the one for performance.

Efficient management of input materials is of utmost importance in a business organization for maximizing materials productivity, which ultimately adds to the profitability of the organization.This requires well coordinated approach towards various issues involving decision making with respect to materials.

All the materials related activities such as material planning & indenting, purchase systems & procedure, variety reduction through standardization & rationalization, reducing uncertainties in demand & supply, handling & transportation, inspection, proper storage & issue of materials to the internal customers, inventory management, vendor management & finally disposal of obsolete, surplus & scrap materials etc. taken together is termed as Integrated Materials Management.

For example, while inventory manager would like to have minimum level of inventory to show of his performance, purchasing manager would like to place bulk orders in order to lessen his work load and show discounts as reductions. Both of these acts may be little contradictory from the organizational point of view. That is if some of the functions were to be handled separately, a conflict of interests may occur.

Therefore, the conflicting objectives need to be balanced and intertwined from a total organizational viewpoint so as to achieve optimum results for the organization as a whole.

In an integrated set up, one materials manager (usually the chief) is responsible for all such inter related functions and he is in a position to exercise control and coordinate all the activities with a view to ensure proper balance of the conflicting objectives of the individual functions.

Advantage of Integrated material management

If the organization is integrated with one another, then there is a reduction of cost in utilization of material with effective usage of resources. The modern nomenclature for this setup is "Integrated Materials Management" and various department managers are involved in the activity of material department. The advantage of integrated materials management is help in achieving the objectives of an organization all together.

- Centralization of authority and responsibility in the material function helps to cut the unnecessary cost involved in the process of material management.
- Central material manager is responsible for all aspects of material requirement in an organization and results in better support and cooperation.
- Integration of material department along with other department makes material manager to give out his performance on purchasing and managing inventory in. easily way.
- The centralization of material function has made it possible to create a new processing system as EDP or MRP to find out the schedule in efficient manner.
- The principal objective of material management is to obtain raw materials, tools, general supplies gets at right time.
- Improve the efficiency inventory control by delivering the material at right time and utilizes it at right place in right quantity.
- The price is controllable in the case of integration material management, because it reduces most of the work assigned.
- Effective classification and codification of material will be possible and common to known by all departments.
- It also reduces the unnecessary correspondence and extra paperwork for effective use of systems.

> ***Check your progress***
>
> 1. Define materials management.
> 2. State the levels of Material Management.

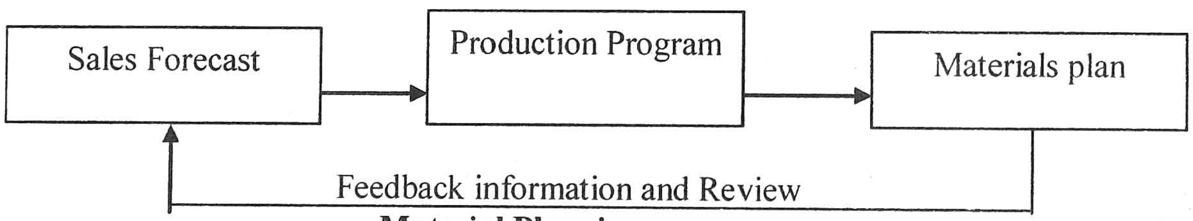
1.3 MATERIAL PLANNING

Material Planning functions and objectives

1. Translation of the sales projections into long term requirements.
2. On the basis of updated production plan adjusted to the latest sales demand to adjust the materials accordingly.
3. To project the facilities required for the materials management.
4. Setting up of consumption standards, for working out requirements.
5. To perform value analysis to determine the intrinsic worth of materials.
6. To keep inventories as low as possible.
7. To procure parts as & when needed by the production/assembly schedule.
8. To decide where to make or buy

Material planning is the scientific way of determining the requirements of raw materials, components, spare and other items that go into meeting production needs within the economic investment policies. Material planning function is a subsystem in the overall production planning and control system. Today with the concept of integrated material management and supply chain management, materials management have learnt that a majority of the material needs of their organizations over a period of one year or so can be forecast in advance with acceptable accuracy.

Material planning, material budgeting and material control have taken prominent roles in the integrated material management. Planning for materials and working out realistic material budget not only help motivate people but also serve as a control device.



Material Planning process

In the context of materials management, planning has to be done for highly non-programmed decisions such as import policy, foreign exchange availability and several other purchasing. Planning has also to be done for highly

programmed decisions such as inventory for working capital, working and delivery schedule.

Factors that affect the Material Planning

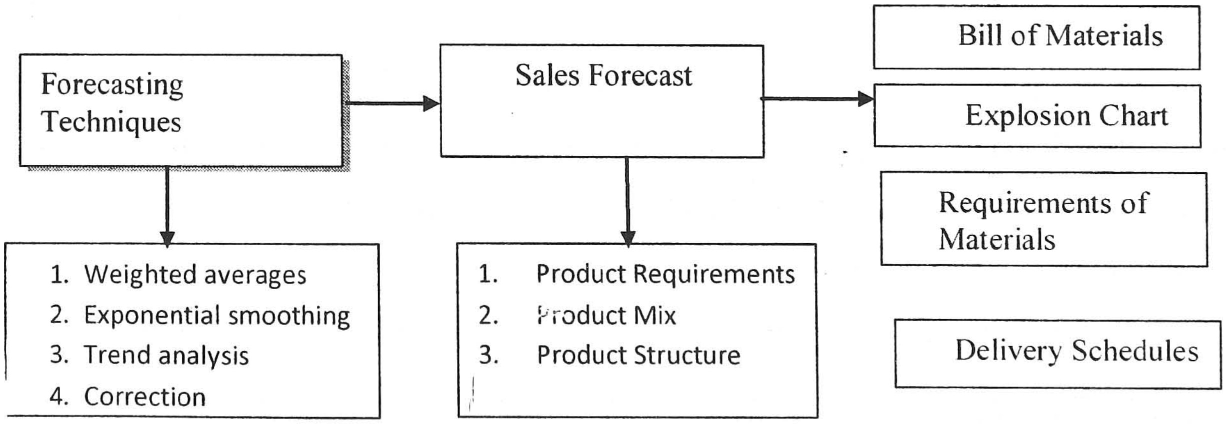
There are many factors, which influence the activity of material planning. These factors can be classified under two categories as macro factors and micro factors.

1. Macro factors: Some of the micro factors which affect material planning, are price trends, business cycles Govt. import policy etc.

2. Micro factors: Some of the micro factors that affect material planning are plant capacity utilization, rejection rates, lead times, inventory levels, working capital, delegation of powers and communication.

1.3.1 Flow diagram for Material Planning

All materials planning subsequently flow from the preliminary master production schedule. Requirements of various materials such as raw materials, tools, equipments, spare parts are worked out by exploding the master production schedule for the planning period through planning horizon. Materials planning can be used to assess the firm requirements for different planning techniques. As the planning propose exceeds one year, the forecast becomes less reliable. Normally, planning is done on a quarterly basis. This is because the materials planner, at the beginning of every quarterly will find that some materials are in short supply and some in excess, owing to errors in forecasting. Thus, operating on a quarterly period is sufficiently long enough in more cases; realistic ordering can be done with the suppliers. The flow diagrams are shown below:



The techniques used for material planning insist a main aspect in master production schedule is bill of materials. Bill of materials is nothing but a document which shows for a given product or subunit, the list of materials re-

quired, unit consumption, and storage quantity. The condition of supply such as "bought out" or "made in house" will also be indicated.

Another approach to material planning is based on past consumption analysis. This method is used for items that are consumed on a continuous basis and for which no bills of materials can be prepared. The past consumption data is analyzed and a projection for the future is made, taking into account the past and future production of products.

Factors affecting Material Planning

The various factors influencing the material planning process are classified as: a) Macro factors and b) Micro factors. Macro factors which affect material planning are price trends, business cycle, import policy of the government, credit policy etc.,

National economy: This is measured by gross domestic production in which production of all sectors is added up by central statistics organization. It is one of the indicators of the health of the economy.

Price Trends: This shown in laws of demand and supply, i.e., when price increases, demand of the goods decreases whereas when price decreases, demand for the goods increases.

Monetary and Fiscal policy of government: a) credit regulation b) guidelines for import and export c) foreign exchange regulation, d) import policy. The material is to be imported comes under the Open General License (OGL) or a need for license, through liberalization and globalization.

Business cycles: These are the result of recession or inflation in world economy.

Micro Factors

The material planner also has to take various factors into account at micro level. They include corporate objectives, plan capacity utilization, rejection rates, lead time, inventory levels, working capital, seasonality, delegation of powers, quality of products producing and purchasing, selection of suppliers, transportation, delivery modes and internal communication systems.

1.4 MATERIAL BUDGETING

Budget is defined as a quantitative expression in money terms of a plan of action related to the accompanying period. It is always expressed in terms of money and quantity. Budget lays down the policy to be followed during the budget period for achieving organizational goals. Budgeting is the

process by which the management allocates the resources evaluates the financial outcome of its decisions and establishes the financial and operational profile against which future results will be measured. The terms budgeting and budgetary control are often used interchangeably. Budgetary control is the comparison of the actual operations resulted with the planned results and finding out the reasons for variations. The forthcoming year's sales target is based on appropriate forecast and defines the capital needed, production plans and other functional budgets.

Budgeting need:

1. Understand why organizations budget and the processes they use to create budgets.
2. Prepare a sales budget, including a schedule of expected cash receipts.
3. Prepare a production budget.
4. Prepare a direct materials budget, including a schedule of expected cash disbursements for the purchase of materials.
5. Prepare a direct labor budget.
6. Prepare a manufacturing overhead budget.
7. Prepare a selling and administrative budget.
8. Prepare a cash budget.
9. Prepare a budgeted income statement.
10. Prepare a budgeted balance sheet.

Operating Budget

The operating budget, reflected in the projected income statement, is the centre piece of the budgeting system. It is built up in terms of:

- Sales forecast
- Production budget
- Materials and purchases budgets
- Labor cost budget
- Manufacturing overhead budget
- Non-manufacturing cost budget

Sales Forecast:

The sales forecast or budget for the forthcoming (budget) year is usually the starting point of the budgetary exercise. Production, inventory, and ex-

penses are factors related to the level of sales. The short-term sales forecast, usually covering a period of one year, is part of a long-term sales forecast which may cover a period of three to five years. It focuses on the current slice of the long run sales forecast in much sharper relief. The sales forecast or sales budget underlies almost all other budgets. So a rational and intelligent effort should be made to develop a sales budget which the top management believes can be reasonably accomplished.

In developing the sales forecast, the following factors should be considered.

- The outlook of the industry and economy
- Past behavior and emerging trends in sales
- Governmental regulations and controls affecting the industry Consumer attitudes, dispositions, tastes, and preferences
- The nature and the extent of competition
- Sales promotion efforts of the firm

Production Budget

In a manufacturing organization, the budget of production is one of the important parts of the operating budget. A well-balanced production plan is required to ensure economical manufacturing. The factors that influence the plan of production are:

(i) The volume and timing of sales budget,

(ii) Inventory policy,

(iii) Productive capacity.

The production plan is geared to meet the requirements of sales. Goods flow from the production line largely in conformity with the needs of sales. There may, however, be significant divergence between the pattern of sales and the pattern of production. This happens fewer than two conditions:

- There is a pronounced seasonal variation in sales whereas production is planned in a stable manner;
- Production necessarily has to be carried out during a certain period of the year, whereas sales occur round the year though there may be some seasonal variation.

The steps involved in preparing the production budget are broadly as follows:

- Assess the productive capacity of the firm.
- Specify the finished goods inventory policy of the firm.

- Estimate the total quantity of each product to be manufactured during the budget period on the basis of sales forecast and finished goods inventory policy.
- Schedule the production during the budget period, taking into account the pattern of sales, the finished goods inventory policy, and the productive capacity.

Materials and Purchases Budgets:

Once the production budget defines the quantities to be produced, the next logical step is to estimate the material requirements and determine the purchase programmer. In this context, the following principal budgets are developed.

Materials Budget:

Materials used in a manufacturing unit are traditionally classified as direct and indirect. Direct materials are materials which are directly identified with the product and are visibly incorporated in it. Indirect materials cannot be traced directly to the product. The materials budget generally is concerned only with direct materials. Indirect materials and supplies are covered by the manufacturing overhead budget. The materials budget shows the quantities, and often the prices, of materials planned to be purchased.

Purchase Budget:

a. The quantities of each type of raw material to be purchased,

b. The schedule of purchases,

c. The estimated cost of purchases.

In developing the purchase budget, one has to take into account the following: (i) the quantities specified in the materials budget, (ii) the planned changes in material inventories, (iii) re-order levels of various inventory items, and (iv) Economic order quantities of various inventory items.

Materials Inventory Budget:

This budget shows the planned raw material levels at certain points in the budgeting period.

Cost of Raw Materials Used Budget:

This budget shows the estimated cost of raw materials to be used from inventory for production.

Labor Cost Budget:

Labor is generally classified as direct and indirect. Direct labor cost rep-

resents the wages paid to workers employed directly in the manufacturing activity. Indirect labor cost represents all other labor costs, such as supervisory salaries, wages paid to storekeepers, maintenance personnel, janitors, and so forth. The budget for labor cost normally includes the cost of direct labor only. The cost of indirect labor is included in the manufacturing overhead budget.

The following approaches may be used for developing the labor cost budget:

- Estimate the labor cost per unit of production by multiplying the standard direct labor hours required for each unit of production by the average wage rate per hour. Multiply the number of units of finished goods planned to be produced by the labor cost per unit in order to get the labor cost budget.
- Estimate the labor cost on the basis of its relationship to some measure such as material cost.

When the above approaches cannot be used, the labor cost budget may be developed on the basis of information about (i) permanent manpower employed in direct manufacturing activity and their remuneration rates, (ii) payments likely to arise on account of overtime work, and (iii) temporary manpower that may be needed and their remuneration rates.

Check your progress

3. List any six responsibilities of material manager.
4. List any four Objectives of Integrated Material Management.

Manufacturing Overhead Budget:

Manufacturing overhead is that part of factory cost which is not included in direct material and direct labor cost. Not directly identifiable with specific products or jobs, manufacturing overhead consists of: (i) indirect material, (ii) indirect labor, and (iii) miscellaneous factory expense items, such as depreciation, utilities, supplies, repairs and maintenance, insurance, taxes, etc.

To construct the manufacturing overhead budget, expense budgets for all the departments in the factory — production as well as service departments — have to be drawn up and aggregated. For this purpose, the expected volume of work to be done in each department has to be determined in terms of an indicator appropriate to its activity. Some measures of activity are given below:

- **For producing departments - Units of output**
  - Direct labor hours
  - Direct machine hours
- **For service departments**

a) Repair and maintenance - direct repair hours or the number of machines to be maintained.

b) Purchase department - total purchases in rupees or the number of purchase orders to be placed.

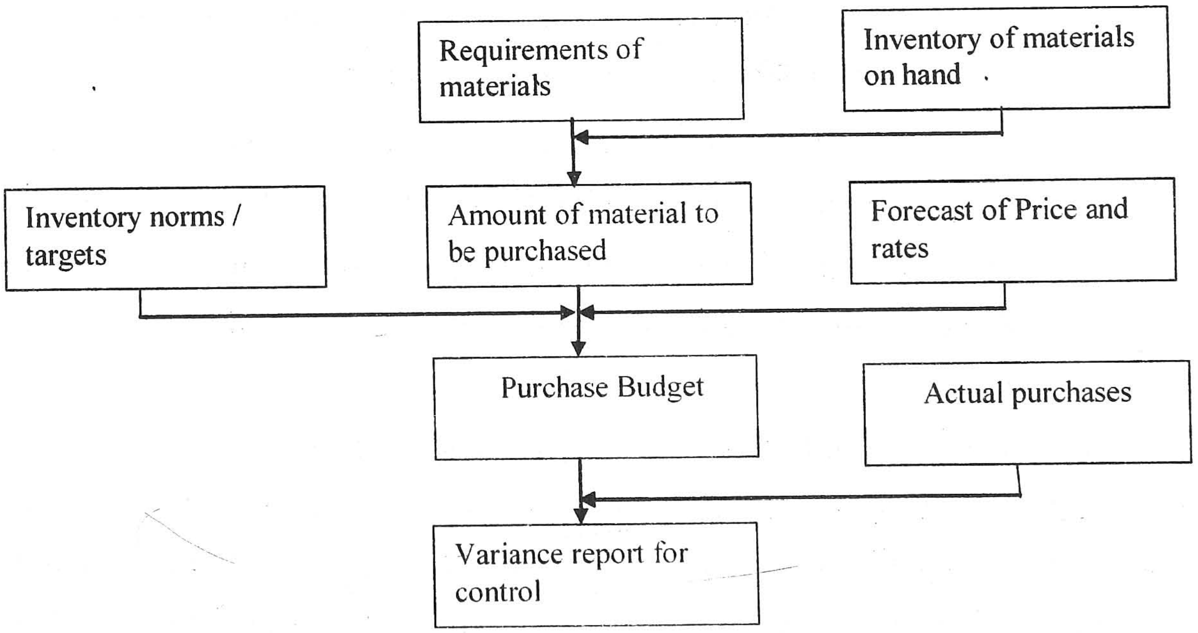
c) General factory administration-number of employees in the plant or total direct labour hours.

Given the activity level of each department in terms of a suitable measure, departmental budgets are drawn in terms of two basic components: the variable cost and the fixed cost. The former is related to the proposed level of activity; the latter is planned independently.

Budget for Non-manufacturing Costs:

Non-manufacturing costs consist of expenses for selling and distribution, general administration, research and development, and financing. The budgets for non-manufacturing costs are normally prepared along departmental lines. For each non-manufacturing department the budget may be developed as the budget for manufacturing overhead is constructed. This may be divided into fixed costs and variable costs. The variable costs of a non-manufacturing department, of course, would have to be related to some index of activity which is meaningful in its context.

1.4.1 Process of Material Budgeting



Material budget can be prepared once the material requirements are planned in the overall budget. The process of budgeting as derived from material requirements is represented in the overall purchase of materials for current

or financial year. Material budget shows estimate quantity as well as the cost of each type of material required for producing the number of units in the production budget. First, quantities of different types of materials are estimated. The price of material and components are purchased and consumed at the cost of materials estimated in the production cost.

The purchase budget includes the material cost and other necessary things required for the day to day activities in an organization. It takes account of inventory on hand and orders to be done. Also, the budget may be formulated to attain certain targeted inventory levels as per the inventory policy of materials management. Usually budgets are formulated both in terms of quantity and money value of materials to be purchased over a period of time. The financial control aspects is highlighted whenever budgeted expenditure norms are exceeded or actual expenditure falls short of budgeted expenditure. The variances are reported at the end of budgeted period and corrective action is taken according to the requirement. The main purposes served by material budget are:

a) The material management department knows exactly its resource availability so that it can plan its purchases and long term contracts in the most optimum manner taking into account and price trends, market position, etc.,

b) To record the prices on which the budget was formed and to compare it finally with the actual prices so that controllable and uncontrollable elements are clearly brought out.

c) To help the financial management of materials by clearly stating the cash requirements for the budget period as well as shorter period.

d) The cash requirement for purchasing materials can be clearly projected for the budgeted period and also time period as on planning horizons.

The basic material budget is prepared based on the sales forecast and the planned production volume for the budgeted period. The flexible budget makes use of supplementary data which adjusted variable costs in accordance with the production levels actually experienced. Some firms may be able to prepare material budgets only for selected key materials.

1.5 SUMMARY

Materials management is an organizational concept in which a single

manager has authority and responsibility for all activities, principally concerned with the flow of materials into an organization. Activities are purchasing, planning and scheduling, maintaining the incoming and outgoing materials, inventory control, and record maintenance. Materials management serves various functions such as material planning, scheduling, purchasing, receiving, store keeping, material handling, inventory control, and scrap and surplus disposal. These functions should always yield optimum results for the better working of other departments in an organization.

Material management is also an important area of management like production, marketing, finance and human resource management. In enterprises where the cost of materials is a major part of the cost of production, material management is not considered as a sub function of production, but considered as equal to production management, but in small or medium scale industries the material management function is considered as a part of production management function. Efficient management of input materials is of utmost importance in a business organization for maximizing material productivity, which ultimately adds to the profitability of the organization. This requires well coordinated approach towards various issues involving decision making with respect to materials. Material planning is the scientific way of determining the requirements of raw materials, components, spare and other items that go into meeting production needs within the economic investment policies. Material planning function is a sub-system in the overall production planning and control system. Budget is defined as a quantitative expression in money terms of a plan of action related to the accompanying period. It is always expressed in terms of money and quantity of materials with a time frame. The sales forecast or budget for the forthcoming (budget) year is usually the starting point of the budgetary exercise. Production, inventory and expenses are factors related to the level of sales. Material budget can be prepared once the material requirements are planned in the overall budget. The process of budgeting as derived from material requirements is represented in the overall purchase of materials for current or forthcoming financial year.

1.6 ANSWERS TO CHECK YOUR PROGRESS

1. Material Management is a total concept involving an organizational structure unifying into a single responsibility, the systematic flow and control of material from identification of the need through customer delivery.

2. Three Levels of Material Management

Purchasing:

Pay low price for the best value obtained

Negotiation

Vendor selection

Right quality at right time

Storage:

Minimizing transportation and handling costs

adequate and proper storage and preservation of materials

store as per requirement

Movement:

distribution of finished goods to customer

disposal of raw material

3. **To minimize material cost.**

To procure and provide materials of desired quality, when required at the lowest possible overall cost of the concern.

To purchase, receive, handling and store keeping efficiently and reduce the related costs.

To trace new sources of supply and to develop cordial relations with them in order to ensure continuous material supply at reasonable rates.

4. Material planning and sourcing, Purchasing, Stores keeping, Inventory planning, Scheduling and Receiving, warehousing, and transportation.

1.7 FURTHER READING

- J. M. Apple, Plant Layout and Material Handling, 3rd edition (NY: John Wiley and Sons, 1997)
- D. P. Cook, C. H. Goh and C. H. Chung, (1999) "Production and Operations Management" Vol. 8 (3), pp. 318-338.

FORECASTING

NOTES

2.1 Introduction to Forecasting

2.2 Forecasting Models

2.3 Time Series Analysis

2.4 Exponential Smoothing

2.5 Applications of forecasting

2.6 Business forecasting methods

2.7 Summary

2.8 Answers to "Check Your Progress"

2.9 Further Reading

2.1 INTRODUCTION

"Forecasting involves making projections about future performance on the basis of historical and current data."

Forecasting is the first step in planning. It is defined as estimating the future demand for products and services the resources necessary to produce these outputs. Forecast helps managers by reducing some of the uncertainties, thereby enabling them to develop more meaningful plans. A forecast is an estimate about the future. Effective approach of forecasting and preparing the forecasts have became integral part of business planning. Forecast help managers to determine the present course of action along with the consideration of material availability for the future.

Forecasting is the art and science of predicting future events. It is a mere a guess or prediction about the future without any rational basis. It may involve taking historical data and projecting them into the future. It may include a manager's good judgment or subjective or initiative prediction in the absence of historical data.

Steps in Forecasting Process

There are seven basic steps that involved in forecasting process:

1. **Determine the purpose (Objective) of the forecast:** The first step determines when the forecast is required and what is the objective of doing this forecast? The answer for above question makes us to understand main aspects of doing the forecast and the level of details we are going generate for our purpose within a specific time limit.

2. **Select the item for which forecast is needed:** Determine whether the forecast is doing for the single product or group of product or for analyzing the necessity of the product.
3. **Determine the time period of forecast:** The forecast is done for short term or long term, generally most of the forecast is short term because the result may end in failure which incurred the overhead expenses more.
4. **Select the forecasting model:** Determine whether which type of statistical model will suit for the forecast by considering the purpose, time and object using for the forecast.
5. **Gather and analysis the data needed for the product:** Before preparing the forecast, data must be gathered and analyzed. Identity any assumption that are made in conjunction with preparing and using the model of forecast.
6. **Prepare the forecast:** preparation of forecast can be with the related method and data availability.
7. **Monitor the forecast:** Monitor the forecast to determine whether it is performing satisfactorily or not, it may review further for getting the better result related to the purpose of the forecast.

2.2 FORECASTING MODELS

The forecasting techniques can be classified into qualitative technique and quantitative techniques. Qualitative techniques use subjective approaches. These are useful where no data is available and are useful for new products. Quantitative techniques are based on historical data. These are more accurate and computers can be used to speedup the process.

Qualitative techniques

Market Research

Firms often hire outside companies that specialize in market research to conduct this type of forecasting. This also referred as market survey. Market research is used mostly for product research in the sense of looking for new product ideas, likes and dislikes about existing products, which competitive products within a particular area for preference and so on. Market research helps to know the particular segment in the respective market.

Delphi method

Delphi method is a forecasting technique applied to subjective nature of demand values. In this method several experts are asked to give their views on the demand based on the value and cost estimation. The expert may provide several opinions. Based on their opinions of the experts, a consensus will be arrived at the demand of products or advanced technologies used for the process. The essential precautions to be followed in this method are as follows:

a) Panel members must be unknown to each other.

b) The initial questionnaire should be unambiguous and it should explain every matter about the topic of discussion

After getting the opinions from the panel members, they are to compared for similarity. If the variation among the opinion is too much, the summary of opinions is to be circulated again among the members without mentioning the names of persons who given his opinion.

So, Delphi method is an iterative process until the panel converges on a specific values or a range of values as defined by the required accuracy, or arrives at a consensus on the matter under consideration.

Qualitative vs. Quantitative Methods

Qualitative forecasting techniques are subjective, based on the opinion and judgment of consumers, experts; appropriate when past data is not available. It is usually applied to intermediate-long range decisions.

Example of qualitative forecasting methods:

- Informed opinion and judgment
- Delphi method
- Market research
- Historical life-cycle Analogy.

Quantitative forecasting models are used to estimate future demands as a function of past data: appropriate when past data is available. It is usually applied to short-intermediate range decisions.

Example of Quantitative forecasting methods:

- Last period demand
- Arithmetic Average
- Simple Moving Average (N-Period)
- Weighted Moving Average (N-period)

- Simple Exponential Smoothing
- Multiplicative Seasonal Indexes

NOTES

Naïve Approach

Naïve forecasts are the most cost-effective and efficient objective forecasting model, and provide a benchmark against which more sophisticated models can be compared. For stable time series data, this approach says that the forecast for any period equals the previous period's actual value.

Causal / econometric forecasting methods

Some forecasting methods use the assumption that it is possible to identify the underlying factors that might influence the variable that is being forecast. For example, including information about weather conditions might improve the ability of a model to predict umbrella sales. This is a model of seasonality which shows a regular pattern of up and down fluctuations. In addition to weather, seasonality can also be due to holidays and customs such as predicting that sales in college football apparel will be higher during football season as opposed to the off season.

Casual forecasting methods are also subject to the discretion of the forecaster. There are several informal methods which do not have strict algorithms, but rather modest and unstructured guidance. One can forecast based on, for example, linear relationships. If one variable is linearly related to the other for a long enough period of time, it may be beneficial to predict such a relationship in the future. This is quite different from the aforementioned model of seasonality whose graph would more closely resemble a sine or cosine wave. The most important factor when performing this operation is using concrete and substantiated data. Forecasting off of another forecast produces inconclusive and possibly erroneous results.

2.3 TIME SERIES ANALYSIS

Time series forecasting models try to predict the future based on past data. The time series model is always recognize with terms such as short, medium and long. For business forecasting, short term are usually used for analyzing the context of business with current scenarios. Medium and long term analysis generally refers more than two years and it mostly help to view the seasonal effects and their trends. Time series forecasting model is chosen based on:

a) Time horizon to forecast

b) Data availability

c) Accuracy required

d) Size of forecasting budget

e) Availability of quantified personnel.

Time series analysis model has several characteristics:

Simple Moving Average Method

A simple moving average is a method where a specified number of recent data values in a series is added and find out the average for values. In otherwise, a time period containing number of data points is averaged by dividing the sum of the point values by number of points. The formula for computing simple moving average is:

$$M_t = (D_{t-(n-1)} + D_{t-(n-2)} + \dots\dots\dots + D_{t-2} + D_{t-1} + D_t) / n$$

Where,

M_t - simple moving average at the end of period t.

D_t – actual demand in period t.

n – Number of periods include in each average.

Weighted moving Average

Equal weights were assigned to all periods in the computation of the simple moving average. The weighted moving average assigns more weight to some demand values (usually the more recent ones) than to others. The formula for weighted moving average is:

$$F_t = w_1 A_{t-1} + w_2 A_{t-2} + w_3 A_{t-3} + \dots\dots + w_n A_{t-n}$$

Where,

A_t - actual occurrence in the past period.

w_1 – weight to be given to the actual occurrence for the period t - 1.

w_n – weight to be given to the actual occurrence for the period t – n.

n – Total number of periods in the forecast.

Linear Regression

Regression means dependence and involves estimating the value of a dependent variables Y, from an independent variable X. In simple regression, only one independent variable is used, where as in multiple regressions two or more independent variables are involved. The simple regression takes the following formula:

$$Y = a + bX$$

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Where,

Y – Dependent variable

X – Independent variable

a – intercept

b – Slope (trend)

2.4 EXPONENTIAL SMOOTHING

Exponential smoothing is a procedure for continually revising a forecast in the light of more recent experience. Exponential Smoothing assigns exponentially decreasing weights as the observation get older. In other words, recent observations are given relatively more weight in forecasting than the older observations. Exponential smoothing is the most used of all forecasting techniques. It is an integral part of virtually all computerized forecasting programs and it is widely used in ordering inventory in retail firms, wholesale companies and service agencies. Exponential smoothing techniques have become well accepted for six major reasons:

- Exponential models are accurate in forecasting.
- Formulation of an exponential model is relatively easy.
- The user can understand how the model works.
- Little computation is required to use the model.
- Computer storage requirements are small because of the limited use of historical data.
- Tests for accuracy as to how well the model is performing are easy to compute.

In the exponential smoothing method, only three pieces of data are needed to forecast the future: the most recent forecast, the actual demand that occurred for that forecast period and a smoothing constant alpha (X). This smoothing constant determines the level of smoothing and the speed of reaction to differences between forecast and occurrences.

Single Exponential Smoothing

Another form of weighted moving average is the exponential smoothed average. This method keeps a running average of demand and adjusts it for each period in proportion to the difference between the latest actual demand value and the latest value of the average.

$$F_t = F_{t-1} + X\,(D_{t-1} - F_{t-1})$$

Where,

F_t - Smoothed average forecast for period t.

F_{t-1} – Pervious period forecast.

X – Smoothing constant, weight gives to pervious data (0<X<1).

D_{t-1} – Pervious period demand.

If X is equal to 1, then the latest forecast would be equal to the previous period actual demand value. The preference range for X is from 0.1 to 0.3.

Trend effect in exponential smoothing

Remember that an upward or downward trend in data collected over a sequence of time periods causes the exponential forecast to always lag behind the actual occurrence. Exponential smoothed forecast can be corrected somewhat by adding in trend adjustment. To correct the trend, we need two smoothing constant, besides the smoothing constant X, the trend equation also uses a smoothing constant delta. The delta reduces the impact of the error that occurs between the actual and the forecast. If both alpha and delta are not included the trend would overreact to error.

Adaptive forecasting:

There are two approaches to controlling the value of alpha, one use various values of alpha. The other uses a tracking signal.

1. **Predetermined values of alpha:** The amount of error between the forecast and the actual demand is measured. Depending on the degree of error, different values of alpha are used.
2. **Tracking values for alpha:** A tracking alpha computes whether the forecast is keeping pace with genuine upward or downward changes in demand. In this application, the tracking alpha is defined as the exponentially smoothed actual error divided by the exponentially smoothed absolute error.

Measuring Forecast Accuracy

Forecast error: Forecast error is a measure of how accurate our forecast was in a given time period. It is calculated as the actual demand minus the forecast, or

$$E_t = A_t - F_t$$

Forecast error in one time period does not convey much information, so we need to look at the accumulation of errors over time. Unfortunately, the

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Check Your Progress

1. Applications of forecasting
2. List down Steps in Forecasting Process
3. List six advantages of Exponential smoothing.

accumulation of the E_t values is not very revealing, for some of them will be positive errors and some will be negative. These positive and negative errors cancel one another, and looking at them alone might give a false sense of security. To illustrate, consider our original data, and the accompanying pair of hypothetical forecasts made with two different forecasting methods.

Year	Actual Demand A_t	Hypothetical Forecasts Made With Method 1 F_t	Forecast Error With Method 1 $A_t - F_t$	Hypothetical Forecasts Made With Method 2 F_t	Forecast Error With Method 2 $A_t - F_t$
1	100	105	-5	160	-60
2	300	310	-10	390	-90
3	200	195	5	110	90
4	500	490	10	620	-120
5	600	585	15	540	60
6	700	715	-15	580	120
Accumulated Forecast Errors			0		0

Based on the accumulated forecast errors over time, the two methods look equally good. But, clearly Method 1 is generating better forecasts than Method 2.

Measuring Forecast Accuracy

Mean Absolute Deviation (MAD): To eliminate the problem of positive errors canceling negative errors, a simple measure is one that looks at the absolute value of the error (size of the deviation, regardless of sign). When we disregard the sign and only consider the size of the error, we refer to this deviation as the absolute deviation. If we accumulate these absolute deviations over time and find the average value of these absolute deviations, we refer to this measure as the mean absolute deviation (MAD). For our hypothetical two forecasting methods, the absolute deviations can be calculated for each year and an average can be obtained for these yearly absolute deviations, as follows:

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Year	Actual Demand A_t	Hypothetical Forecasting Method 1			Hypothetical Forecasting Method 2		
		Forecast F_t	Forecast Error $A_t - F_t$	Absolute Deviation $\lvert A_t - F_t \rvert$	Forecast F_t	Forecast Error $A_t - F_t$	Absolute Deviation $\lvert A_t - F_t \rvert$
1	100	105	-5	5	160	-60	60
2	300	310	-10	10	390	-90	90
3	200	195	5	5	110	90	90
4	500	490	10	10	620	-120	120
5	600	585	15	15	540	60	60
6	700	715	-15	15	580	120	120
	Total Absolute Deviation			60			540
	Mean Absolute Deviation			60/6=10			540/6=90

Clearly Method 1 has provided more accurate forecasts over this six year horizon, as evidenced by its considerably smaller MAD.

Monitoring Forecast Accuracy over Time

Tracking Signal: A tracking signal (T.S.) is a tool used to continually monitor the quality of our forecasting method as we progress through time. Each period a tracking signal value is calculated, and a determination is made as to whether it falls into an acceptable range (much like we saw with control charts). If it drifts outside of the acceptable range, that is an indication that the forecasting method being used is no longer providing accurate forecasts. Tracking signals help to indicate whether there is **bias** creeping into the fore-casting process. Bias is a tendency for the forecast to be persistently under or persistently over the actual value of the data.

Tracking signal is calculated as follows:

$$\text{Tracking signal} = \frac{\text{algebraic sum of forecast errors (ASFE)}}{\text{MAD}}$$

Illustration of the computation of tracking signals to accompany the pro-gression of forecasts made over time with hypothetical forecasting Method 1

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Year	A_t	F_t	$A_t - F_t$	ASFE	$\|A_t - F_t\|$	Total $\|A_t - F_t\|$	MAD	T.S.
1	100	105	-5	-5	5	5	5	-1.00
2	300	310	-10	-15	10	15	7.5	-2.00
3	200	195	5	-10	5	20	6.67	-1.50
4	500	490	10	0	10	30	7.5	0
5	600	585	15	15	15	45	9	+1.67
6	700	715	15	0	15	60	10	0

2.5 APPLICATIONS OF FORECASTING

Forecasting has application in many situations:

- Supply chain management –

  Forecasting can be used in Supply Chain Management to make sure that the right product is at the right place at the right time. Accurate forecasting will help retailers reduce excess inventory and therefore increase profit margin. Accurate forecasting will also help them meet consumer demand.
- Weather forecasting, Flood forecasting and Meteorology
- Transport planning and Transportation forecasting
- Economic forecasting
- Technology forecasting
- Earthquake prediction
- Land use forecasting
- Player and team performance in sports
- Telecommunications forecasting
- Political Forecasting
- Sales Forecasting
- Product forecasting

Check Your Progress.

4. List any six applications of forecasting.
5. Example of qualitative forecasting methods
6. Define budget.

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It is the science of predicting the degree of success a new product will enjoy in the marketplace. To do this, the forecasting model must take into account such things as product awareness, distribution, price, fulfilling unmet needs and competitive alternatives.

Bass model

$$(t) \ / \ (1\text{-}F(t)) \quad = p + (q/m) \ N(t)$$

Where,

- F(t) is the probability of adoption at time t
- f(t) is the rate at which adoption is changing with respect to t
- N(t) is the number of adopters at time t
- m is the total number of consumers who will eventually adopt
- p is the coefficient of innovation
- q is the coefficient of imitation

Multivariate techniques such as regression can be used to determine the values of p, q and N if historical sales data is available. The **Bass diffusion model** was developed by Frank Bass and describes the process of how new products get adopted as an interaction between users and potential users. It has been described as one of the most famous empirical generalizations in marketing, along with the Dirichlet model of repeat buying and brand choice. The model is widely used in forecasting, especially product forecasting and technology forecasting. Mathematically, the basic Bass diffusion is a Riccati equation with constant coefficients.

2.6 BUSINESS FORECASTING METHODS

Forecasting, planning and goals

Forecasting is a common statistical task in business, where it helps inform decisions about scheduling of production, transportation and personnel. and provides a guide to long-term strategic planning. However, business forecasting is often done poorly and is frequently con- fused with planning and goals. They are three different things.

Forecasting: is about predicting the future as accurately as possible, given all the information available including historical data and knowledge of any future events that might impact the forecasts.

Goals: Is what you would like to happen. Goals should be linked to forecasts and plans, but this does not always occur. Too often, goals are set

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without any plan for how to achieve them, and no forecasts for whether they are realistic.

Planning: is a response to forecasts and goals. Planning involves determining the appropriate actions that are required to make your forecasts match your goals.

Forecasting should be an integral part of the decision-making activities of management, as it can play an important role in many areas of a company. Modern organizations require short-, medium- and long-term forecasts, depending on the specific application.

Short-term forecast: is needed for scheduling of personnel, production and transportation. As part of the scheduling process, forecasts of demand are often also required.

Medium-term forecast: is needed to determine future resource requirements in order to purchase raw materials, hire personnel, or buy machinery and equipment.

Long-term forecast is used in strategic planning. Such decisions must take account of market opportunities, environmental factors and internal resources.

An organization needs to develop a forecasting system involving several approaches to predicting uncertain events. Such forecasting systems require the development of expertise in identifying forecasting problems, applying a range of forecasting methods, selecting appropriate methods for each problem, and evaluating and refining forecasting methods over time. It is also important to have strong organizational support for the use of formal forecasting methods if they are to be used successfully.

Commonly used methods

Typically, businesses use relatively simple forecasting methods that are often not based on statistical modeling. However, the use of statistical forecasting is growing and some of the most commonly used methods are listed below.

Time series methods

- Simple exponential smoothing was developed in the 1950s (Brown 1959) and has been widely used ever since forecasts can be computed recursively as each new data point is observed:
- Holt's linear method (Holt 1957) is an extension of simple expo-

nential forecasting that allows a locally linear trend to be extrapolated.

- For seasonal data, a popular method is the Holt-Winters method, also introduced in Holt (1957), which extends Holt's method to include seasonal terms.
- There is also a multiplicative version of the Holt-Winters method, and damped trend versions of both Holt's linear method and the Holt-Winters method (Makridakis et al. 1998).

None of these methods are explicitly based on underlying time series models, and as a result the estimation of parameters and the computation of prediction intervals is often not done. However, all the above methods have recently been shown to be optimal for some state space models (Hyndman et al. 2008), and maximum likelihood estimation of parameters, statistical model selection and computation of prediction intervals is now becoming more widespread.

Other time series models sometimes used in business forecasting include ARIMA models, GARCH models (especially in finance), structural models and neural networks.

Explanatory models for forecasting

The use of explanatory models in business forecasting does not have such a long history as the use of time series methods.

- **Linear regression** modeling is now widely used (e.g., Pardoe 2006) where a variable to be forecast is modeled as linear combination of potential input variables.
- An interesting application of regression model to forecasting is given by Byron & Ashenfelter (1995) who use a simple regression model to predict the quality of a Grange wine using simple weather variables. However, it is far more common for regression modeling to be used to explain historical variation than for it to be used for forecasting purposes.
- In advertising, there is a well-developed culture of using distributed lag regression models (e.g., Hanssens et al. 2001).

These are various models involved in forecasting and in the various activities of business.

2.7 SUMMARY

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Forecasting is the first step in planning. It is defined as estimating the future demand for products and services - the resources necessary to produce these outputs. Forecasting is the art and science of predicting future events. It is a mere a guess or prediction about the future without any rational basis. It may involve taking historical data and projecting them into the future. The forecasting techniques can be classified into qualitative technique and quantitative techniques. Firms often hire outside companies that specialize in market research to conduct this type of forecasting. Delphi method is an iterative process until the panel converges on a specific values or a range of values as defined by the required accuracy, or arrives at a consensus on the matter under consideration.

Some forecasting methods use the assumption that it is possible to identify the underlying factors that might influence the variable that is being forecast. For example, including information about weather conditions might improve the ability of a model to predict umbrella sales. This is a model of seasonality which shows a regular pattern of up and down fluctuations. Time series forecasting models try to predict the future based on past data. The time series model always recognizes with terms such as short, medium and long. Exponential smoothing is a procedure for continually revising a forecast in the light of more recent experience. Forecasting is a common statistical task in business, where it helps to take decisions about scheduling of production, transportation and personnel needed, and provides a guide to long-term strategic planning.

2.8 ANSWERS TO CHECK YOUR PROGRESS

1. Forecasting is the first step in planning. It is defined as estimating the future demand for products and services the resources necessary to produce these outputs. Forecast helps managers by reducing some of the uncertainties, thereby enabling them to develop more meaningful plans. A forecast is an estimate about the future. Effective approach of forecasting and preparing the forecasts have became integral part of business planning. Forecast help managers to determine the present course of action along with the consideration of material availability for the future.

2. **Steps of the forecast:** The first step determines when the forecast is required and what is the objective of doing this forecast? The answer for above question makes us to understand main aspects of doing the forecast and the level of details we are going generate for our purpose within a specific time limit.

➢ **Select the item for which forecast is needed:** Determine whether the forecast is doing for the single product or group of product or for analyzing the necessity of the product.

➢ **Determine the time period of forecast:** The forecast is done for short term or long term, generally most of the forecast is short term because the result may end in failure which incurred the overhead expenses more.

➢ **Select the forecasting model:** Determine whether which type of statistical model will suit for the forecast by considering the purpose, time and object using for the forecast.

➢ **Gather and analysis the data needed for the product:** Before preparing the forecast, data must be gathered and analyzed. Identity any assumption that are made in conjunction with preparing and using the model of forecast.

➢ **Prepare the forecast:** preparation of forecast can be with the related method and data availability.

➢ **Monitor the forecast:** Monitor the forecast to determine whether it is performing satisfactorily or not, it may review further for getting the better result related to the purpose of the forecast.

3. Exponential models are accurate in forecasting.

   Formulation an exponential model is relatively easy.

   The user can understand how the model works.

   Little computation is required to use the model.

   Computer storage requirements are small because of the limited use of historical data. Tests for accuracy as to how well the model is performing are easy to compute.

4. Weather forecasting, Flood forecasting and Meteorology

   Transport planning and Transportation forecasting

   Economic forecasting

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Technology forecasting

Earthquake prediction

Land use forecasting

5. Qualitative forecasting methods:

- o Informed opinion and judgment
- o Delphi method
- o Market research
- o Historical life-cycle Analogy.

6. Budget is defined as a quantitative expression in money terms of a plan of action related to the accompanying period. It is always expressed in terms of money and quantity. Budget lays down the policy to be followed during the budget period for achieving organizational goals.

2.9 FURTHER READING

- B. H. Andrews and S. M. Cunningham, (1998) "L. L. Bean Improves Call-Center Forecasting", Interfaces, Vol. 25 (6), pp 1-13.
- C. S. Galbraith and G. B. Merrill, (1996) "the Politics of Forecasting: Management the Truth", California management Review, Vol. 38 (2), pp. 29-43.
- A. J. Scott, (1984) "Forecasting by Extrapolation: Conclusions from 25 Years of Research" Interfaces, Vol. 14 (6), pp. 52-66.

PURCHASING

3.1 Introduction
3.1.1 Objectives of Purchasing
3.1.2 Functions of Purchasing
3.2 Purchasing Policies
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3.1 INTRODUCTION

The purchasing or procurement function occupies a vital and unique position in an organization. Purchasing is the beginning stage of activity in the production, where the quality and quantity of materials determine the day to day production in industries. Purchasing ensures procuring materials, supplier relationship, machinery and services needed for the production and maintenance of the concern.

Purchasing implies the act of exchange of goods and services for money, whereas procurement is a genuine term with a wider connection for the total responsibility of acquiring goods and services. Purchasing is a managerial function involving planning and policy formulation, research and development strategies required for the selection of materials and source of supply, negotiation for the best price of items and follow up of order and timely delivery. Some of purchasing definitions are:

"**Purchasing** is the business activity directed to secure the material suppliers and equipment required in the operations of an organization" – Fine and Westing

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"Scientific purchasing is the procurement by purchasing of the proper material, machinery, equipments and supplies to stores used in the manufacturing of a product, adapted to marketing in the proper quantity and quality at the proper time and lowest price consistent with the quality desired." – Dr. Walters

Thus, purchasing is concerned with quality product at right time for correct price to match to the cost of production.

3.1.1 Objectives of Purchasing

Purchasing is an important and inevitable activity of any business or non-trading activities. Progressive organizations recognize it as an important function and organize a separate purchase department to look after the purchase function. The objectives of the purchase function must be spelt out clearly for the justification of its independent existence. Moreover, purchasing being the part of the total management activity must see that its objectives are in conformity with the overall objectives of the organization. Identification of objectives encourages the imaginative personnel to accelerate their efforts in attaining them efficiently and economically. Objectives are set by the head of the purchasing department either in consultation with the top management or on the line of the broad policies outlined by the top management.

- To procure the materials and supplies in time for plant requirements and have to deliver them at right place.
- To develop reliable alternative sources of supply in consideration of other external factors such as transportation, discount and mode of payment.
- To develop good supplier relationship and partnership for a long period.
- To keep inventories as low as possible without affecting the planned budget of an organization.
- To implement purchasing techniques such as make or buy decision analysis, cost analysis and value analysis.
- To keep the expenses of purchasing department in control and work along with the objectives of other departments.
- To help keep a minimum Inventory
- To develop policies and procedures which permit accomplishment of the preceding seven objectives at the lowest reasonable operating cost

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- To ensure continuity of supply of raw materials, spare parts and other essential tools for smooth running of production at actual cost.
- Avoidance of duplication, waste and obsolescence
- Maintenance of company's competitive position
- Maintenance of company's good image
- Developing alternative sources of supply

These objectives can be applicable to all manufacturing units, service sectors and industrial buying agents.

3.1.2 Functions of Purchasing

Purchasing function, in a business environment, is one of the most critical functions as it provides the input for the organisation to convert into output. Materials today are lifeblood of industry. They must be available at the proper time, in the proper quantity, at the proper place, and the proper price. Company costs and company profits are greatly affected by them as normally, a manufacturing organisation spends nearly 50% of its revenue in purchasing.

Purchasing Function vs. Purchase department:

Purchasing function is a function commonly seen in all those organisations that undertake purchasing activities. Purchase department is a unit of an organisation that performs purchasing function. The purchasing function is usually performed by a specialized and centralized purchasing department, directed by an efficient manager to achieve the performance in an economical manner.

3.2 Purchasing Policies

Every organization needs purchasing guidelines within which purchasing decisions are made day to day for the process of procuring the materials. A well established policy reduces the time and cost involved in the purchasing process and purchasing decisions become easier at complex situations. Purchasing policies defines the basic decisions of top level management along with objectives of an organization for making a buying process effectively. The various areas to consider in the policy formulation:

- A clear declaration of authority and responsibility in procuring activity.
- A method of maintaining a effective relationship with vendors.
- Proper way of handling the competition and make use of their advantages.
- Reciprocity

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- Personnel involved in the purchasing activity should be trained well with current trend in the market.
- Following of ethics in purchasing procedures.

The purchasing functions are also influenced by certain policies, there are

a) Make or Buy decision
b) Ancillarisation
c) Speculative buying
d) Vendor Rating
e) Reciprocity
f) Value analysis

3.3 PURCHASING PROCESS OR PURCHASING CYCLE

Purchasing is the formal process of buying goods and services. The Purchasing Process can vary from one organization to another, but there are some common key elements. The process usually starts with a 'Demand' or requirements – this could be for a physical part (inventory) or a service. A requisition is generated, which details the requirements (in some cases providing a requirements speciation) which actions the procurement department. A Request for Proposal (RFP) or Request for Quotation (RFQ) is then raised. Suppliers send their quotations in response to the RFQ, and a review is undertaken where the best offer (typically based on price, availability and quality) is given the purchase order.

3.3.1 Steps in the Purchasing Process

The general pattern for handling purchase orders is as follows:

1. A department initiates a request for goods or services and sends it to the Purchasing Department.
2. Purchasing staff verifies that the specifications are complete and selects potential sources.
3. Purchasing staff follows good business practices in determining the best offer for required materials or services. We review quotations based upon:
   - Unit costs and total costs;
   - Completeness of the order and adherence to the specifications listed:

- Delivery costs;
- Delivery time; and
- Warranties, maintenance, installation, etc., e.g., service.

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4. When we award an order, we will FAX or mail a purchase order form containing a purchase order number to place an order. In some circumstances, we may telephone in an order with a purchase order number.
5. You must send an invoice with the purchase order number noted on the invoice to the Accounts Payable Department before a payment can be made.

Purchase Requisition

It refers to the formal information given to purchase department by user department as their requirement for day to day operation in the form of documents called as purchase requisition or purchase index. A purchase requisition is a authorized document with the specification of material, quality, quantity and other specific details of an item. A purchase requisition is usually made by the store or user department for further processing. The requisition should be clear and clarity of information.

Selection of Suppliers

The Purchasing Department staff is responsible for the selection of reputable, dependable suppliers. You should write or phone the purchasing contract manager who makes purchases in the commodity area. New as well as established suppliers should offer competitive prices and continue to act in good faith as far as delivery, adjustments, and other services are concerned. They try to retain the good will of all suppliers by dealing fairly with them at all times. The following aspect has to be seen in selection:

- The production capabilities of a supplier and capacity of day production in present and future.
- The financial strength of the supplier and profitability of the company at present and future.
- Technical capacity such as machinery, equipment and skill of the employees.
- Working condition, industrial relation, raw material purchasing and their quality.
- Delivery system and way of service provided over a time.

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Specifications

Occasionally, we must seek professional services from suppliers in developing specifications for equipment and materials. As a general practice, if you quote a substitute or alternate goods or services, you should clearly note the change and provide documentation. If you have a question about this issue, please call the purchasing contract manager before submitting your quotation.

Requests for Quotations (Price Requests)

An enquiry to the supplier for sending their price, terms and condition in a document format is called quotation. In many instances, after we have verified the specifications, requests for quotations (RFQ) or price requests will be sent to a number of competent suppliers. These requests should be completed, signed, and returned as indicated on the price request form. They consider the pricing information to be binding. You should review the information above under General Information while you are preparing your quotation.

Placing the orders

After selecting the source and the purchase department starts to prepare purchase orders. The purchase order is a starting point of an agreement between the supplier and purchasing organization. Purchase orders (PO) can be of various types, including:

- Standard - a one time buy;
- Planned - an agreement on a specific item at an approximate date; and
- Blanket - an agreement on specific terms and conditions: date and quantity and amount are not specified.

Purchase Orders are normally accompanied by Terms and Conditions which form the contractual agreement of the Transaction. The Supplier then delivers the products/service and the customer records the delivery (in some cases this goes through a Goods Inspection Process. An invoice is sent by the supplier which is cross-checked with the Purchase Order and Document which specifying that the goods received. The payment is made and transferred to GI.

A **purchase order (PO)** is a commercial document issued by a buyer to a seller, indicating types, quantities, and agreed prices for products or services the seller will provide to the buyer. Sending a PO to a supplier constitutes a legal offer to buy products or services. Acceptance of a PO by a seller usually forms a one-off contract between the buyer and seller, so no contract exists

until the PO is accepted. A signed purchase order (PO), an automatic purchase order (APO) [both generate a purchase order number], and a procurement card are the only methods of purchase that obligates for payment. When an emergency arises, a purchasing contract manager may use the telephone or other means of transmission to place an order. However, a purchase order number is always assigned. If you participated in the quotation process but you did not win the order award, you should make an appointment to see the appropriate purchasing contract manager. This will give you:

- Information on how your competitors priced their commodities;
- Information about how you can be more competitive on the next quotation; and
- A basis upon which to begin talking to the departments and the purchasing contract managers about your goods and services.

Receiving the goods

On the receipts of the purchase order, supplier delivered the goods as per the schedule with term and condition of packaging along the invoice, which carries the quantity, purchase order no. and price of materials. The goods are received at the work place for inspection and process is formalized by the document called the goods inward (GI Note).

Payment for goods

If the purchase order calls for the payment after receipt and acceptance of goods, a copy of goods inward note duly certified and endorsed by inward inspection, please forwarded to the accounts department. The accounts department compares the detail of GI note with those of the corresponding purchase order before making to payment to the supplier. Apart from the payments described earlier that could be other terms which call for payments to be made at different stages of supply.

Negotiation

Negotiation is the process of planning, viewing, analyzing and interaction between the buyer and the seller to arrive at a mutually acceptable agreement. True negotiation is not adversarial in nature: it is resolving points of different and finding an amicable solution to buyer and seller relationship. Negotiation can be applied in matters related to pricing, quality, and delivery lead time level of after sales service or even refinement of terms of contract covering liabilities and damage. There are four stages of negotiation:

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Exploration:

In this stage, both parties develop a relationship at first and then they discussed about the transaction of materials and this to avoid conflict between them.

Reflection:

In this stage the points exchanged are digested and through over.

Negotiation:

In this phase the actual negotiation takes place. Concession, discount, pricing factor, payment mode are signed by both side.

Closing:

The agreements are repeated and summarized before the closing of discussion. The written document speaks the value of contract with round off and sharp corners.

The above points are useful to buyers for clear understanding of the seller preferences on purchasing procedures.

3.3.2 How to design a Purchasing Process

With the introduction of modern technology, Purchasing Processes have changing dramatically. Improved methods of communication have meant that Order requests can be transferred electronically, notification of delivery emailed, supplier payments automated.

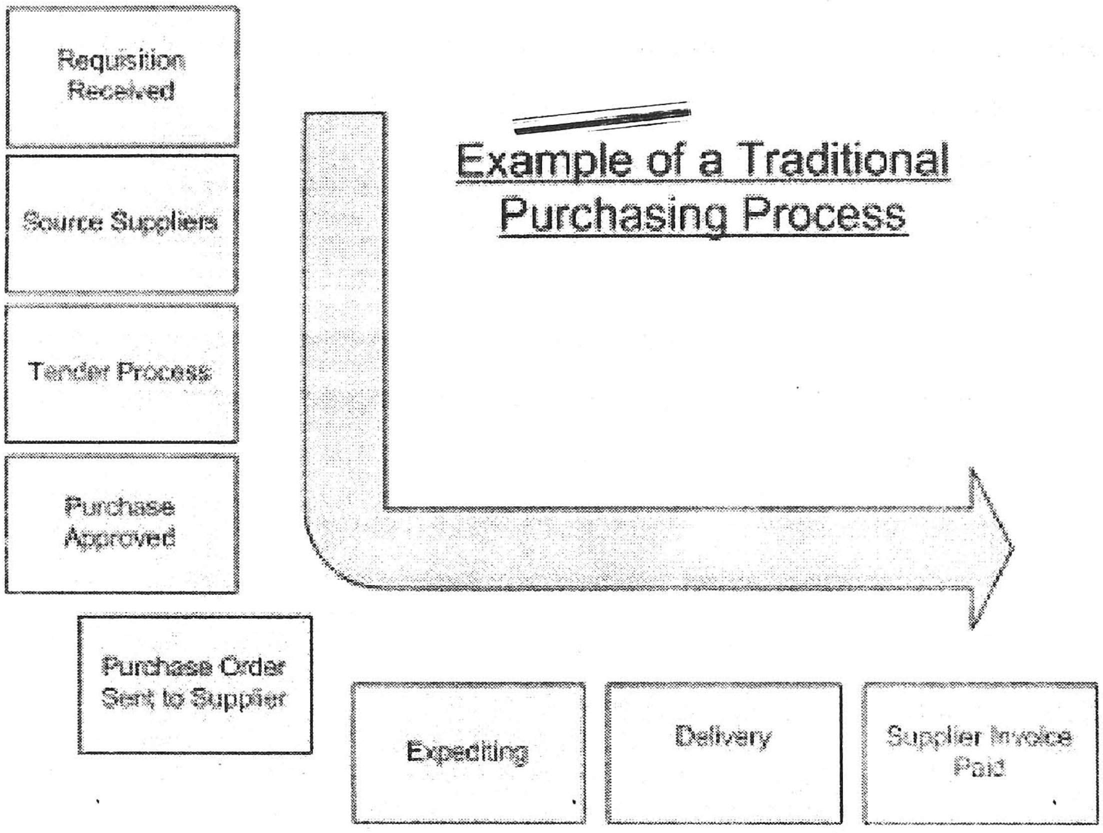
While many businesses may find the utopia of fully automated procurement a strategy rather than reality, purchasing departments often find them in a hybrid where a mixture of technology, partners and culture may be unable to accept a fully automated approach and traditional and contemporary processes co-exist.

In designing purchasing processes it's important to take into account both how information systems can be leveraged and where business constraints and governance exist. Whilst some fundamentals e.g. originating need – communicating the need to the supplier – delivery – the payment of the supplier - may exist in most processes – how they are deployed can vary depending on the overall strategy of the business and the prevalence of, and confidence in, Information Systems.

When designing purchasing processes it's helpful to understand both the traditional and contemporary methods in order to select the appropriate element that applies (or can apply) to your organization.

Traditional Purchasing Process

Where information technology is not heavily ingrained - Traditional Purchasing processes tend to be characterized by high levels of bureaucracy, encumbered with manual authorization (often requiring multiple signatures independent of the order value.), slow communications and a focus on unit price rather than long term commodity arrangements. Due in part to the lack of readily available Management Information. The diagram below provides an example of a traditional purchasing process.



- The process may require authorization at various intervals – including at the requisition, Purchase Order, supplier payment process – this may be multiple authorizations at each stage

  E.g. The operator and his/her supervisor.

- Sourcing and tendering may focus on obtaining multiple cost/availability options from various suppliers rather than leveraging formal long term contracts. There may be little to no pressure on limiting the number of suppliers used.

- Manual Purchase Orders are raised and sent to suppliers – manual acknowledgements are also requested. Communication is slow and paper based.

NOTES

- Periodic expediting activity takes place to ensure delivery schedules are adhered to
- Items are delivered and forms/documents are transferred within the business to close down orders
- Manual invoices are submitted and subject to authorization procedures often requiring signatures to indicate that the Purchasing process has completed satisfactory (and that the order has been met).

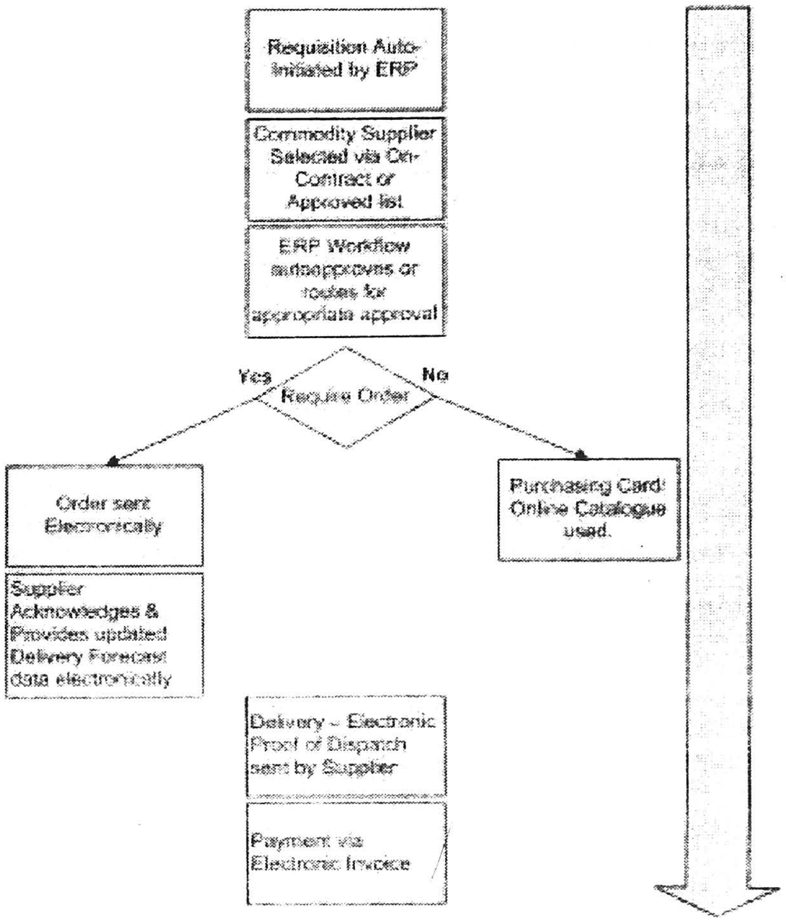
Contemporary Purchasing Process

Where information systems are prevalent much of the authorisation and communication methods that are present in the traditional process can be automated or abolished. Management Information is also more widely available (and of better quality) and enables the organisation to move towards Automated processes which rely more on exception management rather than transaction management.

- The resultant culture is therefore one that focuses more on Supplier Relationship Management and a long term approach that one that focuses purely on Transactions
- Modern ERP systems monitor inventory and trends and automate requisitions based on forecast need
- Automated workflow and approvals engine route requirement to be authorised (where applicable)
- Where formal orders are required suppliers informed electronically either as part of established B2B network or via electronic message. Supplier acknowledgement and changes to terms updated in realtime.
- For low value or less complex commodities – a mixture of Procurement Cards and online catalogues can be used negating the need for formal orders whilst ensuring that robust controls are still in place
- Use of barcodes/RFID speed up the delivery process, electronic messages covering proof of dispatch and delivery are transmitted by the ERP and stakeholders are advised in realtime
- Electronic Invoices are submitted and are matched by the ERP against the Purchase order and delivery and then routed for payment negating the need for human intervention. Where Procurement Cards are used – Transaction Management systems route and aide process activity

NOTES

Example of modern Purchasing Process



Systems can dramatically reduce the amount of paper documents within a purchasing environment while streamlining the process via use of workflow systems

3.3.3 Types of Purchasing:

Considering the nature of business an organisation has there could be different approaches and hence Purchasing can be any of these types:

1. Forward Buying
2. Tender Buying
3. Speculative Buying
4. Systems Contracting
5. Rate Contract
6. Reciprocity
7. Zero Stock buying
8. Blanket Order

NOTES

> ***Check Your Progress***
> 1. Define Purchasing
> 2. What are the steps in Purchasing process

1. Forward Buying :

Forward Buying as the name suggests is the system under which buying is done with longer term in perspective. It is not meant for meeting the present consumption requirement. It is rather a commitment on part of both the buyer and the seller, normally for a period of one year.

A few organisations do "hedge", particularly in the commodity market by selling or buying contracts.

Forward buying helps a firm in booking capacity of a supplier and thus often results into a safeguard against a competitor acquiring his capacity. It is usually done for Raw materials but is not limited to it. Now days, with competition becoming globalised such an arrangement is a win-win situation for both, the buyer and the supplier.

2. Tender Buying:

With competition growing as ever, Information technology replacing the arduous manual mode of purchasing and transparency in dealings more required than ever, many professionally managed firms have started looking for more sources of supplies, beyond their normal boundaries. Not that tender buying did not exist earlier. Rather, it has always been considered the only way of buying materials / services in the government and quasi government procurements.

What is Tender buying ?

As the word suggests, tender buying is selecting a supply source (supplier) out of many sources available. That is, many tenderers are invited to participate in the tendering process and then one or more than one tender is selected for order placement. Such tenders are also called the Accepted tender/s (A/Ts).

The main focus through tender buying is on competition of price and quality. Usually, the best quality (T1 or Q1) is selected after assessment of the technical offers and then the lowest offered price (L1) tender is selected for order placement.

3. Systems contract:

Systems contract, as the term suggest, is a contract of system of buyer with that of the seller. It is a release system in which items, usually, commonly available off-the-shelf, are identified and pre-priced in anticipation of certain usage.

Delivery releases are made against existing orders placed by purchase. This is a procedure intended to help the buyer and the seller to reduce administrative expenses and at the same time to ensure proper controls.

The system authorizes the designated persons of the buyer to place orders directly to the supplier with the specific materials during a given contract period.

The contract is thus finalized only after it is ensured that an attempt has been made to integrate as many buyer-seller materials management functions as possible. In this system the original indent, duly approved by competent authorities, is shipped back with the items and avoiding the usual documents like purchase orders, materials requisitions, expediting letters and acknowledgements, goods in transit report, etc. The contract is simple, covering only delivery period, price and invoicing procedure. Systems contracting is particularly useful for items with low unit price and high consumption profile and thus relieves the buyers of the routine work.

While Systems contract has certain features in common with other purchasing agreements, it is this integration of buyer-seller operations that clearly distinguishes it from other types of contracts.

4. Rate contracts:

Rate contracts are mutual agreements between the buyer and the seller to operate a set of chosen items, during a given period of time, for a fixed price or price variation. Under this system the rates are fixed and at times even the quantity of the selected items. As and when the need arises the buyer issues a Purchase order directly on the basis of the rate chart available on the supplier who in turn supplies the items.

The system of rate contract is prevalent in public sector organistions and government departments. It is common for the suppliers to advertise that they are on "rate contract" with the DGS & D (Directorate General of Supply & Disposal), for the specific period for the given items. After negotiation, the seller and the buyer agree to the rates of items. Application of rate contract helps organisations cut down the internal administrative lead time as individual firms need not go through the central purchasing departments and can place orders directly with the suppliers

5. Reciprocity in Buying

In certain business situations a buyer may give preference to a supplier who also happens to be his customer. This relationship is known as reciprocity. It is something like "I buy from you if you buy from me"

NOTES

> ***Check Your Progress***
>
> 3. What are the types of purchasing
> 4. What are the factors influencing Make or buy decision

One of the main questions for which this, otherwise simple way of buying, is always under the scanner of purchasing ethics is its undue ability to restrict competition and fair play. One of the major roles that any purchaser plays for his firm is in cost reduction arena which is attempted by generating competition among the suppliers

This principle gets a jolt through reciprocity in buying. However, when factors such as quality, after sales service, price etc is equal normally a buyer would like to buy from his customer, if for nothing then at least for having a good working relationship.

However, the distinct disadvantages of reciprocal buying outweigh the limited and narrow advantage that a firm may derive out of it. Some of the main disadvantages of reciprocity are not being able to follow the well laid criteria of quality, price and service.

A purchasing executive should not indulge in reciprocity on his initiative when the terms and conditions are not equal with other suppliers. It is often found that less efficient manufacturers and distributors gain by reciprocity what they are unable to gain by price and quality. Since this tends to discourage competition and might lead to higher prices and fewer suppliers, reciprocity should be practiced on a selective basis.

6. Zero stock buying:

Zero stock buying refers to buying in a manner that the system ensures that the material is delivered by the seller only when it is required and that no prior inventory of the item is maintained by the buyer.

As the competition becomes more intense the need for a lean manufacturing system becomes more focused. Keeping inventory thus is blocking huge money that is idle for the firm. Thus Zero stock buying is more of an inventory safeguard rather than the normal buying.

Normally, under this system the firms try to operate on the basis of zero stock and the supplier holds the stock for these firms.

Usually, the firms of the buyer and seller are close to each other so that the raw material of one is the finished product of another

Alternatively, the system could work well if the seller holds the inventory and if the two parties work in close coordination. However the price per item in this system is slightly higher as the supplier may include the inventory carrying cost in the price. In this system, the buyer need not lock up the

capital and so the purchasing routine is reduced. In practice, the buyer is called upon to pay to the supplier only when the material is delivered as per the need.

For example, in India, say the Indian Oil Limited maintains its petrol and diesel refilling stations inside the manufacturing premises of many companies. As and when petrol or diesel is required, say in a lorry, IOL fills that and a coupon is signed by the driver of the lorry. Buyer makes the payment to IOL against that coupon.

7. Blanket Orders:

Under the **Blanket Order system** an agreement is done between the buyer and the supplier to provide a required quantity of specified items, over a period of time, usually for one year, at an agreed price.

This system minimizes the administrative expenses and is useful for 'C' class items for which rigid controls are not required. Deliveries are made depending upon the buyer's needs. The system relieves the buyer from routine work, giving him more time for focusing attention on high value items such as 'A' and part of 'B' class.

Blanket Order system requires fewer purchase orders and thus reduces clerical work. It often achieves lower prices through quantity discounts by grouping the requirements. The supplier, under the system, maintains adequate inventory to meet the blanket orders, but he does not incur selling costs, once the negotiations are finalized.

3.4 VENDOR RATING OR PERFORMANCE MONITORING

The supplier is evaluated by his ability to perform effectively and consistently over time. It also involves the consideration of basic criteria such as quality, service, delivery and price. The most common used to evaluate supplier are

i) The categorical method

ii) The weighted point method

iii) Cost ratio method

Categorical method

A categorical method of supplier evaluation is based on the experience of supplier in the market. Each supplier is assigned a grade on the basis of various factors such as quality, delivery, price, service etc., It is usual to circulate the evaluation list to the departments, concerned with the suppliers prod-

uct. The personnel from the purchasing department analysis the supplier performances on basic factors and consider the supplier for trouble free supply of that particular material. Each supplier is evaluated on the basis and according to their grade position; they are preferred for further process. Categorical method is simple and easy to administer. But it is subjective and qualitative analysis.

Weighted point method

Weighed point method is assessed on the basis of some selective and important factors. In this method the selective factors are weighted with different points, it varies from company to company and the points are various according to the factors. The evaluation factors are quality, price, delivery, service, location, skills etc., for example 10 points for service, 20 points for quality, 30 points for price. The supplier is evaluated in all the factors and final score makes the supplier to be selected for the purchasing of material. This is frequently used method to determine the vendor performance.

Cost ratio method

The cost ratio method is based on the calculation of the following ratios:

· Quality Cost ratio expresses the ratio of quality costs and the cost of total purchases from the vendor. This is also termed as quality rate(QR)

· Delivery Cost involves the fraction of cost in emergency situation or delayed supply with cost of purchases. This is also termed as delivery rate (DR).

· Service Cost is calculated on the basis of rating the vendor's ability to provide good service in all different critical and normal situations. This is also termed as service rate (SR).

$$\text{Cost Ratio} = QR + DR + SR.$$

Evaluation Indices of Vendor Rating

$$\text{Vendor rating Index (quality)} = \frac{\text{No. of lots rejected}}{\text{No. of lots received}}$$

$$\text{Vendor Rating Index (delivery)} = \frac{\text{Delivery on schedule}}{\text{Total no. of deliveries}}$$

$$\text{Vendor Rating Index (Price)} = \frac{\text{Lowest price bid}}{\text{Price bid by the vendor}}$$

Vendor Rating Index (overall) = VRI (quality) X A + VRI (Delivery) X B + VRI (Price) X C

Whether A, B, C are the weights given to the vendor by the purchasing manager concern.

3.5 MAKE OR BUY DECISION

The purchase decision would be made with a concept called Make or Buy analysis of a particular material. The make or buy decision refers to the problem encountered by an organization when deciding whether a product or a service should be purchased from outside sources or manufactured internally. This analysis is done on the basis of resources availability such as manpower, equipments, machinery, technology, cost of material, space allotted for storage and installment of components. The company should go for this decision when the time involved in manufacturing the product is less and requirement of the material in market is soon.

The majority of the Make or buy decision are made on the basis of price. But this is only one of the criteria which are to be evaluated in this strategic decision. Many of the cost factors encourage long term contracts with the supplier to aid in the achievement of production and quality levels. The investment made for the appropriate resources and new ideas for the future development is more. Top management involves in this strategic decision making.

Factors influencing Make or Buy decision

- Volume of production
- Cost involved in purchasing of components and materials
- Utilization of production capacity
- Integration of production system
- Availability of manpower
- Development of new product and process design
- Availability of competent suppliers
- Quality and reliability of the product.

The functional aspects involved in this Make or Buy decision are:

i) Financial aspects

ii) Technological aspects

iii) Marketing aspects

iv) Purchasing aspects

NOTES

v) Strategic aspects.

These all functional aspects also consider as a factor that to be consider, while going for make or buy decision.

3.5 SUMMARY

The purchasing or procurement function occupies a vital and unique position in an organization. Purchasing is the beginning stage of activity in the production, where the quality and quantity of materials determine the day to day production in industries. Purchasing implies the act of exchange of goods and services for money, whereas procurement is a genuine term with a wider connection for the total responsibility of acquiring goods and services. Purchasing is a managerial function involving planning and policy formulation, research and development strategies required for the selection of materials and source of supply, negotiation for the best price of items and follow up of order and timely delivery.

Purchasing function, in a business environment, is one of the most critical functions as it provides the input for the organisation to convert into output. Every organization needs purchasing guidelines within which purchasing decisions are made day to day for the process of procuring the materials. A purchase order (PO) is a commercial document issued by a buyer to a seller, indicating types, quantities, and agreed prices for products or services the seller will provide to the buyer. With the introduction of modern technology, Purchasing Processes have changing dramatically. Improved methods of communication have meant that Order requests can be transferred electronically, notification of delivery emailed, supplier payments automated. Zero stock buying refers to buying in a manner that the system ensures that the material is delivered by the seller only when it is required and that no prior inventory of the item is maintained by the buyer.

The supplier is evaluated by his ability to perform effectively and consistently over time. It also involves the consideration of basic criteria such as quality, service, delivery and price. The purchase decision would be made with a concept called Make or Buy analysis of a particular material. The make or buy decision refers to the problem encountered by an organization when deciding whether a product or a service should be purchased from outside sources or manufactured internally. This analysis is done on the basis of resources availability such as manpower, equipments, machinery, technology, cost of material, space allotted for storage and installment of components. The com-

pany should go for this decision when the time involved in manufacturing the product is less and requirement of the material in market is soon.

3.6 ANSWERS TO "CHECK YOUR PROGRESS"

1. **Purchasing** is the business activity directed to secure the material suppliers and equipment required in the operations of an organization" – Fine and Westing
2. **The Steps in the Purchasing Process are:-**
   1) A department initiates a request for goods or services and sends it to the Purchasing Department.
   2) Purchasing staff verifies that the specifications are complete and selects potential sources.
   3) Purchasing staff follows good business practices in determining the best offer for required materials or services. We review quotations based upon:
   4) When we award an order, we will FAX or mail a purchase order form containing a purchase order number to place an order. In some circumstances, we may telephone in an order with a purchase order number.
   5) You must send an invoice with the purchase order number noted on the invoice to the Accounts Payable Department before a payment can be made:
3. **The Types of Purchasing are:-**
   1) Forward Buying
   2) Tender Buying
   3) Speculative Buying
   4) Systems Contracting
   5) Rate Contract
   6) Reciprocity
   7) Zero Stock buying
   8) Blanket Order
4. **Factors influencing Make or Buy decision**
   1) Volume of production
   2) Cost involved in purchasing of components and materials

NOTES

3) Utilization of production capacity
4) Integration of production system
5) Availability of manpower
6) Development of new product and process design
7) Availability of competent suppliers
8) Quality and reliability of the product

3.7 FURTHER READING

- F. Ahmed, (1995) "managing Vendors", Business Today, 7-21, pp. 132-136.
- M. Bensaou, (1999) "Portfolios of Buyer-Supplier Relationships", Sloan Management Review, Vol. 40 (4), pp. 35-44.
- G. W. Dickenson, (1966) "An Analysis of Vendour Selection Systems and Decisions", Journal of Purchasing, Vol. 2, pp. 5-17.

CAPITAL EQUIPMENT, LEGAL ASPECTS, ETHICS AND STANDARDIZATION

4.1 Capital Equipment Buying
4.2 Legal Aspects of purchase
4.3 Director General of Supplier and Disposal
4.4 Purchasing Ethics
4.5 Value Analysis
4.6 Standardization
4.6.1 Cost Savings from Standardization
4.6.2 Other Forms of Standardization
4.7 Codification
4.8 Summary
4.9 Answers to "Check Your Progress"
4.10 Further Reading

4.1 CAPITAL EQUIPMENT BUYING

The companies generally feel to invest their profit in total stock by a means of expansion, new equipments and machinery. The following points could be observed for capital equipment buying against the purchase:

a) Capital equipments are non-repetitive, purchase occurring once in ten years or too.

b) The capital equipment purchase is usually differentiate both in procedures and policies from other materials, because of the nature of large investment over a long duration entailing careful budgeting

c) Capital expenditure involves committing major outlays to get uncertain returns in the future.

d) Capital equipment buying involves project generation, project evaluation, project selection and project execution. Hence network analysis and other planning tools play a significant role.

e) For accounting purpose, capital equipment is considered as affixed asset, to be depreciated over the period of its economic life.

f) The equipment buying directly influences the manufacturing operations of an organization and hence is a matter of significant concern to everyone in the company.

g) The new equipment should be compatible with the local environmental conditions.

h) Since many requirements of major equipments are specific and typical for different types of industries, the number of suppliers available is very few and the organization has to decide carefully about the choice of right source.

i) Purchase of major equipments is a result of careful negotiations, arising out of an analyzing of various alternatives available to the company.

j) The legal and contract management, in the case of capital equipment has to be done in a greater depth, as compared to regular items.

k) Whenever possible, the maintenance and operating personnel should be depending to the supplier's plant to assess the maintainability of the equipment in the future.

4.2 LEGAL ASPECTS OF PURCHASE

The purchase manager should be conversant with the basic provision of the following laws:

- The Indian Contract Act 1872.
- The sales of goods Act.
- The Negotiation Instrument Act
- The law relating to Excise Duty and Sales Tax, including those of Import and Export Duties and Foreign exchange Regulations.

Contract Award Procedures

Decision on launching the Procurement Procedure

- All procurement procedures shall be launched by written decision of the Secretary.
- Decisions shall contain at least the basis for the procurement, type of award procedure and the name of the official in charge for conducting of procurement procedure.

Types of Procurement Procedures

A supplies, services or works contract shall be awarded by means of one of the following procedures under the conditions set out in these Rules:

- open procedure;
- restricted procedure;
- competitive request for quotations;
- Negotiated procedure.

Special conditions for use of a negotiated procedure

The Secretariat may award contracts by a negotiated procedure, as described hereinafter:

- In the event when only non compliant bids have been submitted in response to an open

Procedure, and the Secretariat has repeated the procedure on appropriately amended

Terms, provided that the contract conditions of the most lately conducted procedure are not substantially altered;

- In exceptionally peculiar cases of works or services contracts, when the nature of the works or services or the risks attaching thereto do not permit prior overall pricing;
- The Secretariat may award contracts by a negotiated procedure with one potential supplier only if one or more of the following conditions is met:
- There is only one person or company that can provide the contractual services needed and any attempt to obtain offers would only result in one person or company being available to meet the need;
- Where the compatibility of equipment, accessories, replacement parts, or service is of the paramount consideration; The services involve the repair, modification or calibration of equipment and They are to be performed by the manufacturer of the equipment or by the manufacturer's authorized dealer;
- Even though a product is available from various sources, it must for specific reasons be purchased from a specified vendor; procurement of public utility services; the work represents either an intellectual work or a natural continuation of previous work carried out by the economic operators; when the rapid selection is essential; when a requirement is reasonably available from a single supplier; in case of annual maintenance of proprietary software.

Common Provisions on Tender Documents

Essential information and costs

- The Secretariat shall prepare tender documents in a way to secure information about the contract conditions and award procedures sufficient for the bidders to prepare their bids on a genuinely competitive basis.
- Tender documents shall include at least the following information:
  a) Sufficient data on the Secretariat including contact details;
  b) Description of the goods, works or services concerned;
  c) Bills of quantity, technical specifications, terms of reference;
  d) Required time limits for delivery or completion of the object of the purchase;
  e) The award procedure chosen;
  f) Selection criteria establishing the minimum requirements for the qualifications of candidates or bidders, and required information for assessment thereof;
  g) Validity period;
  h) bid security; performance security; and any other securities if required;
  i) Place, date and hour for receipt of request to participate;
  j) Place, date and hour for receipt of bids;
  k) Place, date and hour for opening of bids;
  l) Currencies of prices;
- The Secretariat shall indicate in the tender documents whether or not it authorizes variants. Variants shall be allowed only where the criterion for the award of the contract is the most economically advantageous bid.
- The Secretariat may amend the tender documents anytime during the procurement process. The bidders shall be notified of any such changes simultaneously.at least 5 (five) days before time limit for submission the requests or bids. The Secretariat may prolonge the time limits for submission of the requests or bids if the tender documents are substantionaly altered.
- Standard documents for the procurements procedures set forth by these Rules may be prepared by the Secretariat.

- The tender documents may be charged by the Secretariat. The price has to be equivalent to the costs of preparing the tender documentation.

Provision of Tender Documents

- The Secretariat may, as appropriate, provide the suppliers with tender documents:

  a) Upon supplier's request;

  b) Together with the invitation to bid;

  c) By placing them on its website or using other electronic means.

- The Secretariat must dispatch the tender documents to the suppliers within 3 (three) days after the receipt of the request for the provision of the documents.

4.3 DIRECTOR GENERAL OF SUPPLIES AND DISPOSAL

The Director General of Supplies and Disposals, Central Purchase Organisation are come under the department of commerce (Supply division). These organizations are responsible for:

- Concluding rate contracts for common user items required by various government departments.
- Purchase and inspection of stores for central government departments other than the terms of inspection delegated to these authorities.
- Purchase and inspection of stores for state governments, PSU, autonomous bodies, etc., who delegate to the service of DGS & D.
- To arrange payments for supplier made against contracts placed by DGS & D through office controller of accounts, New Delhi and its branches at Calcutta, Mumbai and Chennai.
- Registration of suppliers and approved Indian & foreign manufacturers and their agents for use of branch agencies of government.
- Whenever required DGS&D ensures to acknowledge the communication within 7 days and to replies within one month. In case of any delay in giving replies DGS&D will inform person / organization before one month time limit and the expected date to reply from them.

Role & Functions of DGS&D

1. **A CENTRAL PURCHASE & QUALITY ASSURANCE ORGANISATION** of Govt. of India, Department of Supply, Ministry of Commerce.
2. In the year 1860, the British Govt. evolved a concept of **CENTRAL BUYING** & set up **INDIA STORES DEPARTMENT** in **LONDON** for meeting procurement needs of Govt. of India.
3. Established in 1951 in its present form for rendering procurement services to Central & State Govt. by placing Rate Contracts for common user items & contracts against their ad-hoc demands.
4. Adhoc procurement decentralized in December, 1991. Main function now is to conclude **RATE CONTRACTS.**
5. Quality assurance functions continue to remain centralized as before.
6. Continues to be the **NODAL** Agency of Govt. of India for purchase policy & procedure.
7. Govt. Departments/Organisations, who have not built-up their own infrastructure for purchase, can raise their demands on **DGS&D** for adhoc procurement.
8. Handling procurement against several **WORLD BANK & ASIAN DEVELOPMENT BANK** aided projects for modernisation of **POLYTECHNICS & VOCATIONAL TRAINING CENTRES, NATIONAL AIDS CONTROL. NATIONAL/ STATE HIGHWAYS**, Hydrology Project
9. Services continue to be available to **PUBLIC SECTOR UNDERTAKINGS & AUTONOMOUS BODIES.**
10. Has a full fledged **QUALITY ASSURANCE WING** rendering wide ranging technical services inclusive of formulation of need based procurement specifications, vendor development/evaluation and assuring quality of goods for their conformity? Service charges range from 0.25 to 2 %.
11. Cargo clearance services at major ports are available.
12. Manned by qualified Engineers recruited through Indian Engineering Service Examination by UPSC, Govt. of India.
13. State Governments, Public Undertakings, Autonomous Bodies, Quasi Public Bodies, etc. who desire to avail the services of DGS&D can do so. However, indent from these departments should be accompanied by

a pre-deposit of funds sufficient to cover the cost of stores. Pre-deposit of funds may be in the form of demand draft or crossed cheque drawn on the Reserve Bank of India/State Bank of India duly marked 'On Government Account Only' and in favour of Chief Controller of Accounts, department of Supply, New Delhi.

14. Consultancy services of DGS&D are offered to desirous organisations for availing R/C prices, finalising tender documents for their own procurement and providing quality assurance support.
15. Databank on supplier's rate contracts is maintained to arrange supplies of clothing and tentage items etc. for meeting emergency requirements during disasters/natural calamities.
16. Facility for training in Quality & Purchase management field are also available in DGS&D
17. Consultancy Disaster Management

Advantages in Associating with DGS&D

To Suppliers

- Its **REGISTRATION** is held in high esteem by all Govt. Department/ Agencies
- Award of rate contract lends respectability & image enhancement.
- Marketing effort requires is nominal.
- Consistent & uniform purchase policies & procedures.
- Availability of technical guidance for upgrading manufacturing processes & for building product quality.
- Uniform Quality Assurance techniques lead to standardization.
- Registered suppliers are given prior intimation about tenders.

To Buyers

- Facility of bulk purchase of lowest competitive price.
- Enables buying as & when required.
- Saves effort involved in tedious & frequent tendering.
- Just in Time availability of supplies for inventory management.
- Availability of quality goods with full quality assurance back-up.

4.4 PURCHASING ETHICS

Ethics is a set of rules and regulation framed up for doing any activity in the right sense. Purchasing ethics generally tells about the method of doing

the purchasing activity without leaving any procedures involved in purchasing cycle and make a business strategy that should affect the competitors in wrong sense. The most common ethical problem facing the buyer is the avoidance of any action that places him in a position of obligation to a vendor. Gifts or entertainment or a close personal relationship of sales personnel may lead to favoritism.

Another ethical problem is that of maintaining a competitive fair atmosphere among vendors. The buyer may give a vendor misleading information either competitive offers or about the conditions of the contract in order to force him to improve his proposal. To exert undue pressure on a supplier is also an unethical practice which the buyer may be tempted to use. Purchasing department should follow the strict ethical policy in all process of purchasing within the organization and suppliers. On the side of the purchasing department, they should have clear procedure for getting the quotation, processing the quotation and finalizing the supplier. Ordering has to be documented with the particulars such as specification of material, quantity, quality, delivery date of the product and mode of payment. During the time of delivery, inspection of material should be done along the ordering document and end the process of purchasing in an ethical manner.

> ***Check Your Progress***
>
> 1. What are the types of procurement process
> 2. What is value analysis

4.5 VALUE ANALYSIS

Value analysis involves systematized techniques for reducing costs and improving the performance of materials, components and manufacturing processes. Value analysis is defined as "an intensive appraised of all the elements of the design, manufacturing or construction, procurement, inspection, installation and maintenance of a product and its components including the applicable specification and operational requirements in order to achieve the necessary performance, maintainability and reliability of an item at minimum cost."

Value analysis is an organized creative approach which has for its purpose, the efficient identification of unnecessary cost i.e., cost which does not add to quality, use, life, appearance or other customer features. Value analysis should not be treated as a cost reduction technique which makes the product become cheaper in price and high in quality.

Value analysis should be applied in the following cases:

- Company's products are loosing in the market and there is a decline in sales.
- Company's products are priced higher than the competitors.

- New design of products being undertaken.
- Symptoms of disproportionate increase in cost of production.
- Decreasing profitability and return on investment.
- Company failure to meet its delivery commitment.

Value Analysis in purchasing

Value analysis refers to the function of purchased parts and materials in an effort to reduce the cost and improve the performance of those items. From the purchasing, value analysis represents a relatively recent change from concentrating on finding the best price for a certain item to satisfy an intended function. Purchasing cannot perform an investigation each time in materials ordering. Purchasing does not have authority to substitute or modify materials design by operating quantity. It can make suggest to operating units, designers and suppliers, which may lead to improve the performance of purchased goods.

Purchasing can offer a different perspective to the analysis and purchasing people because of their association with suppliers, processes information and others of an organization. If a fair amount of technical knowledge is required to review a parts or products, a team can be formed with representatives from design and operation to work with purchasing in conducting value analysis.

Steps of Value Analysis Process

There are several steps in conducting value analysis, there are

- Establishing the objectives i.e., reduction of cost.
- Consider a multi disciplinary team from marketing, sales, production, supplier and purchasing.
- Analyze the production process of the supplier company. This would include decoupling the cost at each step of the production process.
- Analyze the use of product at the purchasers firm phase by phase.
- Decompose and analyze the various characteristics of the purchased product, applying a weighting coefficient to each according to its importance, characteristics would include physical, chemical composition and process.
- Hold a creative brainstorming session to explore all alternative possibilities, with the team having no preconceived ideas.
- Sort the ideas to establish the cost of each.
- Select the best alternatives.
- Develop a plan for implementing the change.

4.6 STANDARDIZATION

Standardization supports the fundamental precepts of build-to-order and mass customization: All parts must be available at all points of use, not just "somewhere in the plant," which eliminates the setup to find, load, or kit parts. As a stand-alone program, standardization can reduce cost and improve flexibility.

Standardization makes it easier for parts to be pulled into assembly (instead of ordering and waiting) by reducing the number of part types to the point where the remaining few standard parts can receive the focus to arrange demand-pull just-in-time deliveries. Fewer types of parts ordered in larger quantities reduce part cost and material overhead cost.

The Zero-Based Standardization Approach

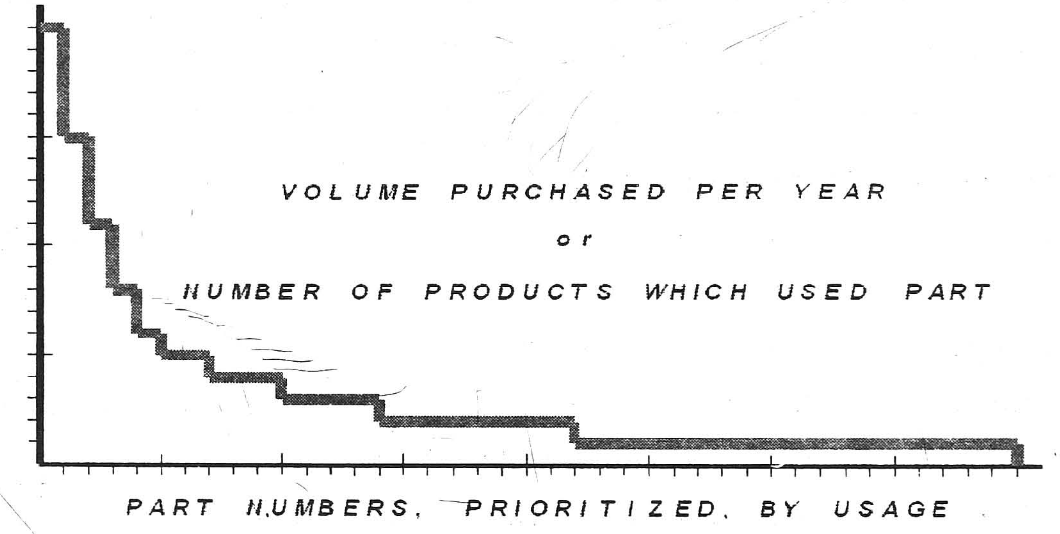
This is a very effective technique to reduce the number of different parts (part types) by standardizing on certain preferred parts. This usually applies to purchase parts but it could also apply to manufactured parts. The methodology is based on a zero-based principle that asks the simple question: "What is the minimum list of part types we need to design new products?" Answering this question can be made easier by assuming that the company (or a new competitor) has just entered this product line and is deciding which parts will be needed for a whole new product line. One of the advantages of new competitors the ability to "start fresh" without the old "baggage:" too many parts. Just image a competitor simultaneously designed the entire product line around common parts. Now image doing the same thing internally. This is called the zero based approach.

The zero based approach, literally, starts at zero and adds only what is needed, as opposed to reducing parts from a overwhelming list. An analogous situation would be cleaning out the most cluttered drawer in a desk, a purse, or a glove compartment; removing unwanted pieces would take much effort, and still not be very effective. The more effective zero-based approach would be to empty everything, and add back only the items that are essential. Where the "clutter" ends up is the difference in the approaches: in the drawer, purse or glove compartment or in the garbage can. Similarly, parts reduction efforts have to work hard to remove the clutter (excess part variety) in the system, whereas zero-based approaches exclude the clutter from the beginning. The clutter is the unnecessary parts that would have not been needed if products were designed around common parts. Not only do these excess parts incur

overhead costs to administer them, they also lower plant efficiency and machine utilization because of the setup caused by product that are designed to have more parts than can be distributed at every point of use.

Standard Parts List Determination consists of the following steps:

- Establish baseline list from usage history (see graph below)
- Add new generation parts
- Eliminate parallel lines of parts (tolerance, strength, etc.)
- Investigate and optimize availability and sourcing
- Structure parts lists into some logical order
- Obtain feedback and concurrence from Engineering, Manufacturing, Quality and Purchasing.



This approach determines the minimum list of parts needed for *new* designs and is not intended to eliminate parts used on existing products, except, when the common parts are functionally equivalent in all respects. In this case the new common part may be substituted as an equivalent part or a "better-than" substitution, where a common part with a better tolerance can replace its lesser counterpart in existing products.

Even if part Standardization efforts only apply to new products, remember that in these days of rapid product obsolescence and short product life cycles, all older products may be phased out in a few years.

4.6.1 Cost Savings from Standardization

Purchasing Leverage - Being able to order larger quantities of standard parts and materials provides purchasing leverage where buyers can benefit from

suppliers economies-of-scale and arrange more frequent deliveries, to support just-in-time operations.

Lowering Material Overhead - There is far less material overhead to procure standard parts and materials, which are more common, more readily available, and have more sources. When asked during Design for Manufacturability classes, purchasing managers say that their effort to procure standard parts is 5% to 10% of the effort to procure the rest of proliferated parts lists. Thus, material overhead for standard part is ten times less and the material overhead rate should be structured accordingly. In the article on measuring total cost, the easy procedure to use to quantify overhead would be to split the material overhead so that standard parts are charged 10% of the total material overhead and the unusual parts are charged 90% to (a) reflect the real costs and (b) to encourage use of the standard parts and materials.

Spontaneous Resupply Possible - Many costs can be reduced by arranging spontaneous resupply of parts and materials, instead of the more expensive forecast-based purchase orders and holding inventories.

4.6.2 Other Forms of Standardization

Tool Standardization - A subject related to part Standardization is tool Standardization, which determines how many different tools are required for assembly, alignment, calibration, testing, repair, and service. Company-wide tool standardization can be determined as follows: Analyze tools used for existing products. Prioritize usage histories to determine the most "common" of existing tools. Work with people in manufacturing/service to determine tool preferences. Coordinate common tool selection with common part selection. Issue common tool lists with common parts lists.

Feature Standardization - "Features" are any geometry that requires a separate tool like a drill, ream, whole punch, bend radii, and cutting tool bit for machine tools. These tools need to be standardized using the same procedures as parts.

Raw Materials Standardization - If raw materials can be standardized, then the processes can be flexible enough to make different products without any setup to change materials, featuring mechanisms, or cutting tools. Raw material Standardization can apply to bar stock/tubing, sheet-metal, molding/casting, protective coatings, and programmable chips.

Process Standardization - Standardization of processes results from the concurrent engineering of products and processes to ensure that the processes

are actually *specified* by the design team, rather than being left to chance or "to be determined later." Processes must be coordinated and common enough to ensure that all parts and products in the mass customization platform can be built without the setup changes that would undermine flexible manufacturing. Example: auto-feed screwdrivers.

EFFECT ON SUPPLIERS

Standardization of parts helps part suppliers rationalize their product lines and allow them to:

· Reduce their overhead costs and subsidies, which allows them to be more cost competitive

· Improve their operational flexibility, resulting in better delivery.

· Simplify their supply chain management,

· Free valuable resources to improve operations and quality, implement better product development practices, and introduce new capabilities like build-to-order & mass customization.

STANDARDIZATION BENEFITS

Cost Reduction

- Purchasing costs reduced through purchasing leverage
- Inventory cost reduction
- Floor space reduction
- BOM/MRP/ordering expense avoided when common parts are simply drawn as needed from spontaneous resupply
- Overhead cost reduction

Quality:

- Product quality
- Continuous Improvement
- Vendor reduction

Flexibility:

- Eliminating setup
- Inventory reduction
- Simplify supply chain management
- Internal material logistics
- Bread truck deliveries
- Flexible manufacturing

Responsiveness:

- Build-to-Order
- Parts availability
- Quicker deliveries from vendors

4.7 CODIFICATION

Codification enables systematic grouping of similar items and avoids confusion caused by long description of the items. Since standardization of names is achieved through codification, it serves as the starting point of simplification and standardization. It helps on avoiding duplication of terms and results in the minimization of the number items leading to accurate records. Codification enables easy recognition of an item in stores, thereby reducing clerical efforts to the minimum. If items are added are coded according to the sources, it is possible to store the items while ordering. To maximize the advantage, it is necessary to develop the codes with all concerned, namely personnel from design, production, engineering, inspection maintenance and materials.

Process of Codification

Codification is a process of representing each item by a number, the digits of which indicate the group, type and specification of an item. Many organizations in public and private sectors, DGS&D have their own system of codification, varying in the method of coding and items group according to the convenient of their usage and remembrance. Codification generally denotes the item code as their first two letters of alphabets followed by the digits or code with entire numerical digits of first two digits give the item code for their series of same or related materials.

The codification process could be obtained by the nature of items and grouping it belongs too. The system codification could be built by the end use of items i.e., items grouped according to the maintenance, packing, work shop etc., the codification could be on the basis of source of purchasing where the items are procured from the source. The codification could also be built on the basis of alphabetical listing.

It can also be done by numerical digit; each code should uniquely represent one item. It should be simple and differentiate according to items from various supplier or unit wise or lot wise. Its also have combination with English letters for having special codes for the material which are frequently used in an organization. Codification should be compact, concise, consistent

and flexible enough to accommodate new items. It should be meaningful and oriented towards the need of an individual organization. The grouping of codification is namely:

a) Alphabetical system

b) Numerical system

c) Decimal system

d) Alphanumerical system

e) Brisch system and

f) Kodak system.

Important Terms to Remember

- **Purchase Requisition** – A departmental request for a standard purchase order required by policy and procedure or vendor. Typically used for transactions over $2,000. Purchase requisitions created in IBIS.
- **Purchasing Card ("Pcard")** – A Visa card issued by PNC Bank assigned to an employee in a Penn State department for business purposes. Used when transactions are low dollar and low-risk and a purchase order is not required. Often a preferred method of payment for Internet and point-of-sale purchases.
- **Purchase Order** – Order placed with a supplier by Procurement at the request of department by purchase requisition because policy and procedure or supplier requires it. Typically used for transactions over $2,000.
- **University Contract** – Enhanced contracts that Procurement establishes with selected suppliers in order to maximize the purchasing power of the University while reducing the overall cost of goods and services.
- **Supplier** – A provider of goods and services that typically is incorporated, bills on an invoice and has multiple transactions with the University.
- **Sole Source Justification** – Document required when a specified vendor and/or manufacturer is indicated as the desired single or sole source and justification is provided in writing.
- **Standing Order** – Open-ended purchase order placed by Procurement at the request of a department by purchase requisition. Allows

NOTES

for addition of items and/or extension of time. Requirements used in volume and purchased repetitively over a period of time may be bought in this manner, although use of the purchasing card is encouraged.

- **Cost savings** – Spending less than previously spent or less than quoted options.
- **Cost avoidance** – Reduction or elimination of a new cost that would have otherwise occurred.
- **Receiving Report** – Form used to transmit to Purchasing Services the fact that material or services ordered on a Purchase Order (PURC or paper PO) has been received at the specified location. This will permit charges against a departmental budget, payment to the vendor, and closure of the order in the database and in Purchasing Services.
- **Partial Receiving Report** – Form used to provide a means of notifying Purchasing Services that partial shipments have been received against a Purchase Order. This form permits charges against a departmental budget and payment to the vendor.

Check Your Progress

3. What is standardization
4. What is purchase order

1.8 SUMMARY

The companies generally feel to invest their profit in total stock by a means of expansion, new equipments and machinery. The Director General of Supplies and Disposals, Central Purchase Organisation are come under the department of commerce (Supply division). Ethics is a set of rules and regulation framed up for doing any activity in the right sense. Purchasing ethics generally tells about the method of doing the purchasing activity without leaving any procedures involved in purchasing cycle and make a business strategy that should affect the competitors in wrong sense. The most common ethical problem facing the buyer is the avoidance of any action that places him in a position of obligation to a vendor. Gifts or entertainment or a close personal relationship of sales personnel may lead to favoritism.

Value analysis involves systematized techniques for reducing costs and improving the performance of materials, components and manufacturing processes. Value analysis is defined as "an intensive appraised of all the elements of the design, manufacturing or construction, procurement, inspection, installation and maintenance of a product and its components including the applicable specification and operational requirements in order to achieve the neces-

sary performance, maintainability and reliability of an item at minimum cost." Standardization supports the fundamental precepts of build-to-order and mass customization: All parts must be available at all points of use, not just "somewhere in the plant," which eliminates the setup to find, load, or kit parts. As a stand-alone program, standardization can reduce cost and improve flexibility. The zero based approach, literally, starts at zero and adds only what is needed, as opposed to reducing parts from a overwhelming list

4.9 ANSWERS TO "CHECK YOUR PROGRESS"

1. Types of Procurement Procedures

A supplies, services or works contract shall be awarded by means of one of the following procedures under the conditions set out in these Rules:

1) Open procedure;
2) Restricted procedure;
3) Competitive request for quotations
4) Negotiated procedure.

2. Value analysis is defined as "an intensive appraised of all the elements of the design, manufacturing or construction, procurement, inspection, installation and maintenance of a product and its components including the applicable specification and operational requirements in order to achieve the necessary performance, maintainability and reliability of an item at minimum cost."
3. Standardization supports the fundamental precepts of build-to-order and mass customization: All parts must be available at all points of use, not just "somewhere in the plant," which eliminates the setup to find, load, or kit parts. As a stand-alone program, standardization can reduce cost and improve flexibility
4. Order placed with a supplier by Procurement at the request of department by purchase requisition because policy and procedure or supplier requires it. Typically used for transactions over $2,000.

4.10 FURTHER READING

- H. D. Gupta, (1991) "Inventory Control in Public Sector" Anmol Publications, New Delhi. R. W. Hall, (1983) "Zero Inventories", Homewood: DowJones, Irwin.
- D. Ernest and L. C. Michelon, (1976) "Modern Management Methods" London, Penguin.
- W. L. Gale, (1983) "Value Analysis To Increase Productivity", New York John Wiley and Sons.

CHAPTER 5

INVENTORY MANAGEMENT AND INVENTORY CONTROL

5.1 Introduction to Inventory Control

5.2 Inventory Costs

5.3 Selective Control

5.3.1 ABC Analysis

5.3.2 EOQ Model

5.4 Dynamic inventory models

5.4.1 Q – Systems

5.4.2 P – Systems

5.4.3 Bin system

5.5 Summary

5.6 Answers to "Check Your Progress"

5.7 Further Reading

5.1 INTRODUCTION TO INVENTORY CONTROL,

Inventory (spares and consumables) are kept in main stores/Sub-stores . Inventory is in the form of working capital.

Functions of inventory:

1. Any production process may have imbalances in the consumption of materials. Production rates may also be varying from stage to stage. Hence firms should keep minimum stocks of inventory.
2. Depending upon the consumption rates and lead times for purchase of the materials, inventories are kept in stores.

Inventory Costs

Cost of capital is an important cost. This is the opportunity cost of investing in stocks of inventory.

Procurement cost is the cost associated with tendering, evaluation of bids, ordering and follow up , receipt and inspection of materials etc

Material handling cost is the cost of moving materials from one place to another place with in the factory

Space cost can be considered as the rent paid to the cubic space occupied by inventory.

Cost of administration includes the salary of staff, telephone/fax charges, postal/ courier expenses

Insurance costs are the costs associated with insurance coverage for the stock of materials.

5.2 INVENTORY COSTS:

1. Item Cost, (Rs. P / item)
2. Ordering Cost, (Rs. C_0 / order)
3. Holding (or) Carrying Cost, (Rs. C_c / item / unit time)
4. Shortage Cost, (Rs. C_s / unit / unit time)

1. Item Cost, (Rs. P / item)

This is the cost of the item whether it is manufactured or purchased. If it is manufactured, it includes such items as direct material and labour, indirect material and labour and overhead expenses.

When the item is purchased, the item cost is the purchase price of 1 unit.

2. Ordering Cost, (Rs. C_0 / order)

Administrative and clerical costs are involved in processing a purchasing order, expediting, follow up etc., It include transportation cost also.

When a unit is manufactured, the unit set up cost includes the cost of labour and materials used in the set up and set up testing.

3. Holding (or) Carrying Cost, (Rs. C_c / item / unit time)

If the item is held in stock, the cost involved is the item carrying or holding cost. Some of the costs included in the unit holding cost are:

(a) Locked up capital in inventory (Interest)

(b) Storage – space costs

(c) Items handling costs

(d) Taxes on inventories

(e) Insurance costs

(f) Obsolescence

(g) Deterioration of quality, theft, spillage and damage to items

(h) Cost of maintaining inventory records

4. Shortage Cost, (Rs. C_s / unit / unit time)

The shortage cost is due to the delay in satisfying demand but the demand is eventually satisfied after a period of time. The unit shortage cost includes such item as,

(a) Overtime requirements due to shortage

(b) Cost of expediting

(c) Loss of goodwill of customers due to delay

(d) Lost production time

5.3 SELECTIVE CONTROL

5.3.1 ABC Analysis

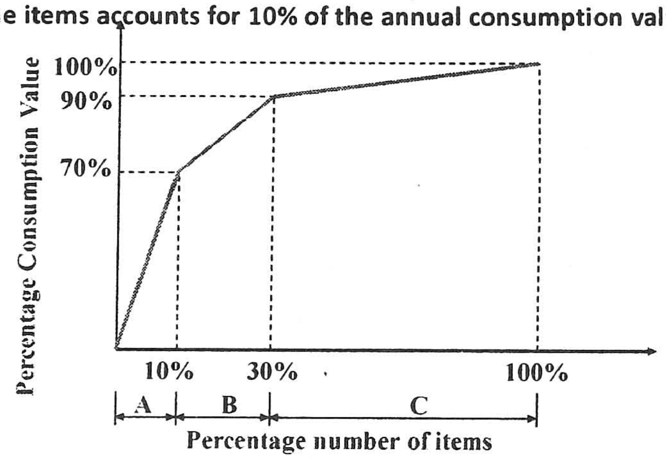
ABC (*Always Better Control*) Analysis

ABC analysis is one such technique which classifies the items into A,B and C class items.

It is clear that 10% of the items accounts 70% of the annual consumption value of the items.

20% of the items accounts for 20% of the annual consumption value of the items, and

70% of the items accounts for 10% of the annual consumption value of the items.



Stocks of inventory are classified as A, B, and C items for selective management control. This is known as ABC analysis. There are various bases for ABC classification- price, weight, size, non-availability etc. ABC analysis is based on the annual consumption value of the items.

Small number of items which account for a large proportion of the annual turnover (in money terms) can be classified as "A" items.

Large number of items which account for a small proportion of the annual turnover (in money terms) can be classified as "C" items.

The balance of items which may be of moderate quantity and value(in money terms) can be classified as "B " items.

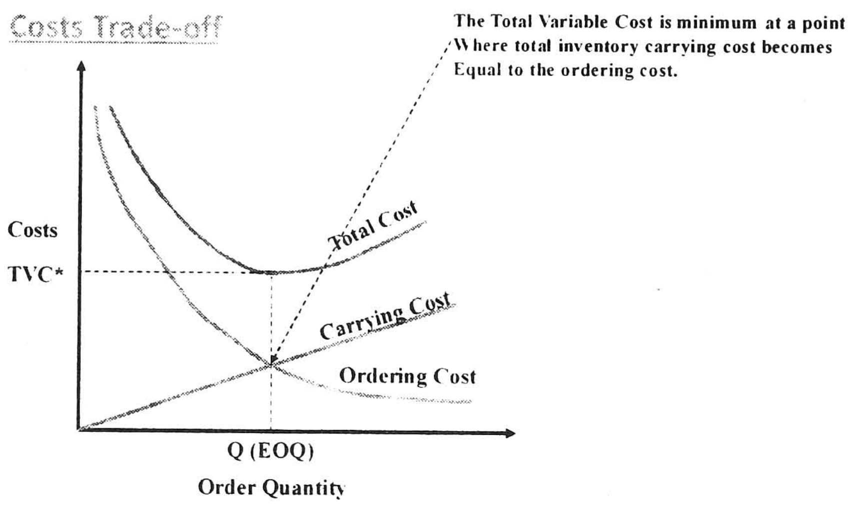
Figure shows that 10% of the items ("A" items) contribute to about 75% of total consumption value of all materials in the inventory. 70% of the

items("C" items) contribute to about 10% of total consumption value of all materials in the inventory and 20% of the items("B" items) contribute to about 15% of total consumption value of all materials in the inventory. ABC classification of the previous year may not necessarily hold good for this year. Percentages mentioned here are only illustrative. It may vary from industry to industry . Classification of items as A or B or C may be reviewed from time to time(every one or 2 years).

A proper ABC analysis will lead to better control over materials and consequent reduction in costs .

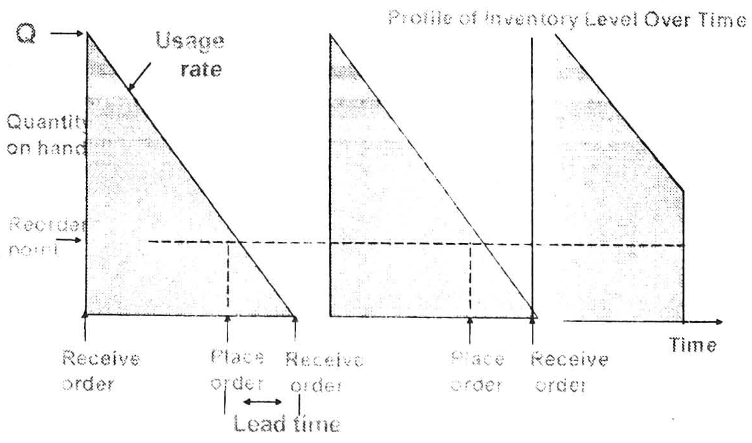
5.3.2 INVENTORY DECISIONS

Economic order quantity (EOQ) is that size of order which minimizes total annual cost of carrying inventory and the cost of ordering under the assumed conditions of certainty and that annual demands are known



The total cost curve represents the sum of ordering cost and carrying cost for each order size. The size at which the total cost is minimum is called Economic Order Quantity (EOQ) or Q (optimal order size)

The Inventory Cycle



Assumptions of EOQ Model :

1. The items are consumed at a constant rate
2. Lead time is assumed to be constant
3. The items are supplied at the end of the lead time after the re-order.
4. The average inventory = Q/2

   Q = Quantity per orders

   A = Annual demand

Cost of carrying (Cc) the inventory per annum= Cc*Q/2

The number of purchase orders placed per year = A/Q

The cost of procurement(Cp) per annum = Cp* A/Q

Total Cost(TC) = Carrying cost + Ordering cost = Cc*Q/2 + Cp* A/Q

Total cost is to be minimized . hence, taking derivative with respect to Q and equating it to zero,

$d(Tc)/dQ = Cc/2 - Cp\ A/\ Q^2$

Economic Order Quantity(EOQ) = Ö 2 C_pA/Cc

> ***Check Your Progress***
>
> 1. What is inventory control?
> 2. What are the various inventory costs?
> 3. Write a short note on ABC analysis.
> 4. What is EOQ?

5.4 MODELS OF INVENTORY

- Purchase model with instantaneous replenishment and without shortages.
- Purchase model with instantaneous replenishment and with shortages.
- Manufacturing model without shortages
- Manufacturing model with shortages

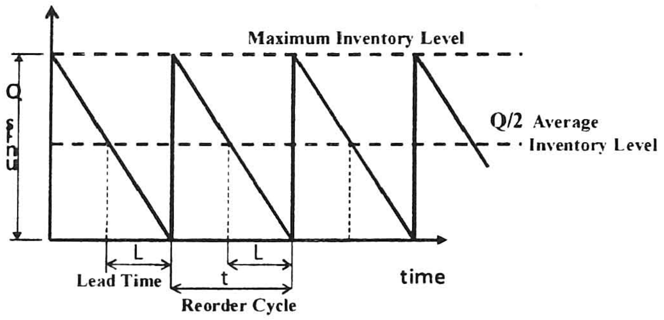
Purchase model with instantaneous replenishment and without shortages

In this model of inventory, orders of equal size are placed at intervals. The items against an order are replenished instantaneously and the items are consumed at a constant rate. The purchase price per unit is the same irrespective of order size.

Let,

- D - be the annual demand in units
- C_0 - be the Ordering cost/order
- C_c - be the Carrying or Holding cost / unit / period
- p - be the purchase price per unit
- Q - be the Economic order size
- L – be the Lead Time
- t - be the Reorder Cycle

Then the corresponding model is



Purchase model without stock out

Annual Ordering Cost

= (No. of orders placed per year) x (Ordering cost per order)

$$= \frac{\text{Annual Demand}}{\text{No. of units in each order}} \times (\text{Ordering cost per order})$$

$$= \frac{D}{Q} \times C_o$$

Annual Carrying Cost

= Average inventory level x Holding cost per unit per year

$$= \frac{Q}{2} \times C_c$$

Since the minimum total cost occurs at the point where the ordering cost and inventory holding cost are equal, i.e.

Ordering cost = Holding cost

$(D/Q) \times C_o = (Q/2) \times C_c$

$$(\text{EOQ}) \quad Q = \frac{2\,D\,C_o}{\sqrt{C_c}}$$

Optimum number of orders placed per year

$$N = \frac{\text{Demand}}{\text{Optimum Order Quantity}} = \frac{D}{Q}$$

Optimum interval between successive orders

$$t_{(\text{in years})} = \frac{\text{Number of working days per year}}{N} = \frac{Q \text{ X days}}{D}$$

t is also called inventory cycle time

Minimum total yearly inventory (variable) cost

$TC_V = (D/Q)\, C_o + (Q/2)\, C_c$ substitute $Q = \sqrt{(2D\, C_o / C_c)}$

$TC_V = \sqrt{2D\, C_o\, C_c}$

Total Variable cost per Year

TC = Material Cost + Variable Cost

$TC = D \times p + (D/Q)\, C_o + (Q/2)\, C_c$

Purchase model with instantaneous replenishment and with shortages

In this model , the items on order will be received instantaneously and they are consumed at a constant rate. If there is no stock at the time of receiving a request for the items, it is assumed that it will be satisfied at a later date with penalty. This is called backordering. The operation of this model is shown in fig.

Let, D - annual demand in units

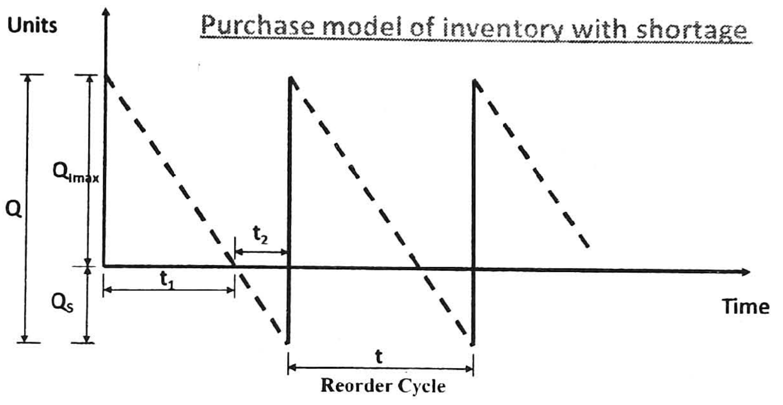
C_0 - Ordering cost/order

C_c - Carrying cost/unit/period

C_s - Shortage cost/unit/period

p - Purchase price per unit

Q - Economic order size



Where

- D - Annual Demand
- Q – Economic order quantity
- Q_{Imax} – Maximum inventory
- Q_S – Maximum stockout
- t_1 - Inventory period
- t_2 – Shortage period

1) EOQ

$$Q = \frac{2\,D\,C_0}{C_c} \quad \frac{C_c + C_s}{C_s}$$

2) Maximum Inventory Level

$$Q_{Imax} = \frac{2\,D\,C}{\sqrt{C_c}} \quad \frac{C_s}{C_c + C_s}$$

3) Maximum Shortage Quantity

$$Q_S = Q - Q_{imax}$$

4) Minimum total yearly inventory (variable) cost

$$TC_V = 2\,D\,C_0\,C_c \quad \frac{C_s}{\sqrt{C_c + C_s}}$$

5) Time between orders

$$t = Q / D$$

6) Inventory period

$$t_1 = Q_1 / D$$

7) Shortage period

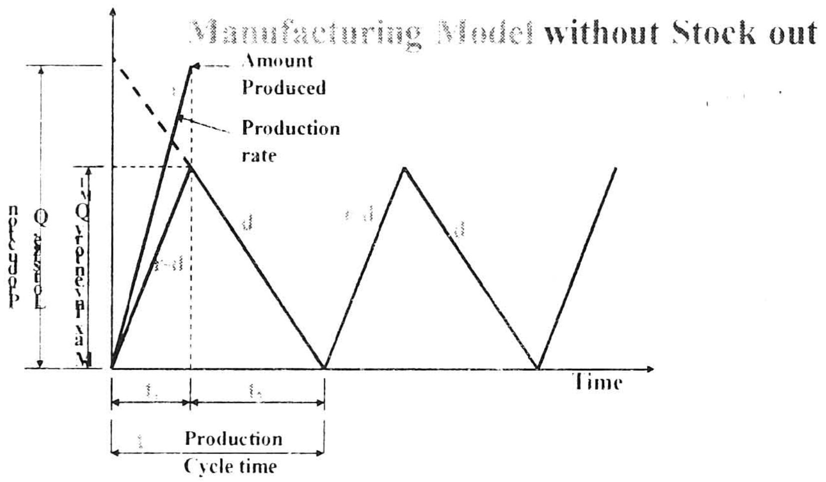
8) Total Cost per Year

$t_2 = Q_2 / D$

TC = Total Material cost + Total variable cost

Manufacturing Model Without Shortages

If a company manufactures its component which is required for its main product, then the corresponding model of inventory is called "Manufacturing model". The rate of consumption of items is uniform throughout the year. The cost of production per unit is same irrespective of production lot size. During the period t_1 the item is produced at the rate of r units per period and simultaneously it is consumed at the rate of d units per period. So, during this period, the inventory is built at the rate of $r-d$ units per period. During the period t_2 the production of the item is discontinued but the consumption of that item is continued. Hence, the inventory is decreased at the rate of d units per period during this period.



D be the annual demand of an item

d usage rate per unit of time

r be the production rate of the item (No. of units produced per year)

C_o be the cost per set up.

C_c be the carrying cost per unit per period

be the cost of production per unit

The various formulas for this situation are given below:

<u>Economic Lot Size</u>

$$\text{or} \quad Q = \frac{2DC_o}{\sqrt{C_c}} \quad \frac{r}{r-d}$$

Economic Set up or Batch Quantity

1. Optimum number of production runs per year

$$N = D / Q$$

2. Optimum length of each lot size production run (production time)

$$t_1 = Q / r$$

3. Production Cycle Time

$$t = (Q / D) \times \text{Number of working days / year}$$

4. Total Minimum yearly inventory (variable) cost

$$TC_V = \frac{D}{Q} C_o + \frac{Q}{2} \frac{r - d}{r} C_c = 2 D C_o C_c \frac{r - d}{\sqrt{r}}$$

5. Max. Inventory

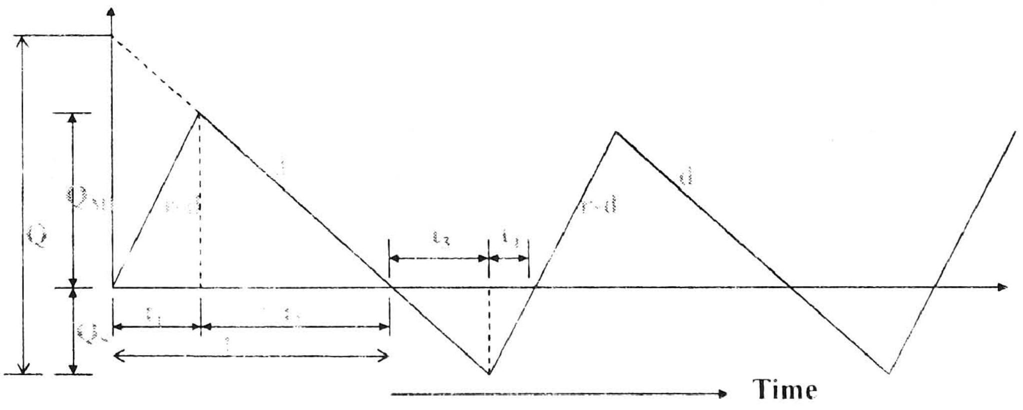
$$Q_{Imax} = Q \frac{r - d}{r}$$

6.Total yearly Variable cost

$$TC = D \times p + \frac{D}{Q} C_o + \frac{Q}{2} \frac{r - d}{r} C_c$$

Manufacturing Model with Shortages

In this model, stock out is permitted. It is assumed that the stock out units will be satisfied from the units which will be produced at a later date with a penalty [illegible]



In the above model,

1) Q – Economic production size

$$Q = EOQ = \sqrt{\frac{2DC_o}{C_c}} \quad \frac{r}{(r-d)} \quad \frac{(C_c + C_s)}{C_s}$$

2) Q_{Imax} – Maximum inventory

$$Q_{MI} = \sqrt{\frac{2DC_o}{C_c}} \quad \frac{(r-d)}{r} \quad \frac{C_s}{(C_c + C_s)}$$

3) Q_S – Maximum stock out

$$Q_S = \sqrt{\frac{2DC_o}{C_s}} \quad \frac{(r-d)}{r} \quad \frac{C_c}{(C_c + C_s)}$$

4. Optimum number of production runs per year

$$N = D / Q$$

5. Production Cycle Time

$$t = Q / D$$

6) $t_1 = Q_{Imax}/(r - d)$

7) $t_2 = Q_{Imax}/d$

8) $t_3 = Q_S/d$

9) $t_4 = Q_S/(r - d)$

10) Minimum total yearly inventory (variable) cost

$$TC = 2DCoCc \quad \sqrt{\frac{Cs}{Cc + Cs}} \quad \frac{r - d}{r}$$

5.4 MODIFICATION OF EOQ UNDER DIFFERENT CONDITIONS. DYNAMIC INVENTORY MODELS,

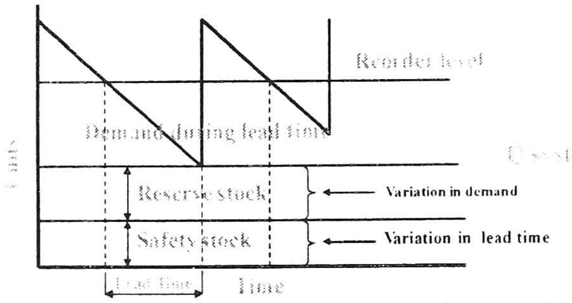
NOTES

IMPLEMENTATION OF PURCHASE INVENTORY MODEL

The practical version of purchase model of inventory can be classified into Fixed Order Quantity System (Q System) and Fixed Period Quantity System (P system)

Fixed Order Quantity System (Q System)

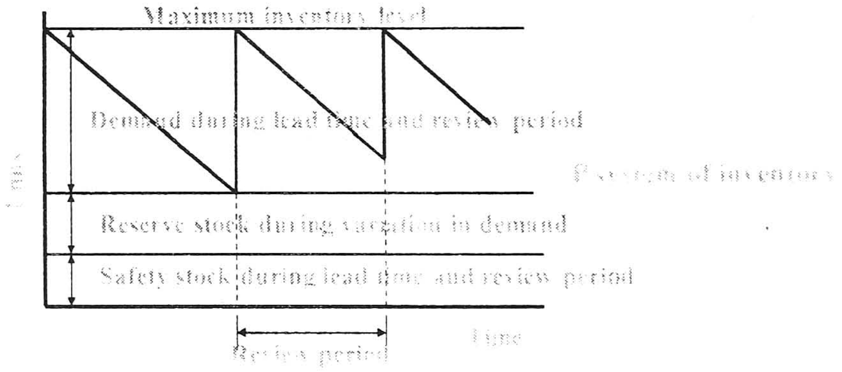
In this system of inventory, whenever the stock level touches the reorder level, an order is placed for a fixed quantity which equal to EOQ.



The average demand during the lead time is known as the demand during lead time (D_{LT}). The variation in demand during lead time is known as safety stock. The average demand during delivery delays is called reserve stock. The reorder level is computed as the sum of the demand during lead time, the safety stock and reserve stock.

Periodic Review System (P System)

In this system of inventory, the stock position is reviewed once in a fixed period and an order is placed depending on the stock position, unlike a fixed quantity in the Q system of inventory. The review period is approximately equal to EOQ/D.



he desired Maximum Inventory Level is fixed as the sum of the average demand during average lead time plus review period, variation in demand during average lead time plus review period, and the average demand during delay in supply.

Deterministic Models of Inventory Management

5.4.1 Q – System(Deterministic Case)

Fig 12.2 The Q system

The stores manager places order for a batch quantity Q whenever the stock level reaches a prefixed level called Reorder level. In this model, the order batch quantity and the reorder level is fixed. This model is best suited when the demand for a product is fluctuating. The chance of shortage is less in this model.

5.4.2 The P – System(Deterministic Case)

Refer to Fig 12. 4

P = Review period

M = Safety Stock

q1, q2 = order quantity

In this model, Stores Manager places order for materials after reviewing the stock level at a fixed interval P. in this model, the maximum stock level is fixed at T. This model is suitable when a supplier provides a variety of items and the demand does not fluctuate.

Probabilistic Models of Inventory Management

P System(Probabilistic case)

In the industry, both Q and P systems are in wide use . based on economics and management practices, P or Q system is followed in industries. However, P system is preferred to the Q system with respect to the following conditions;

a. The P system can be used when orders must be placed at specified intervals .

b. The P system can be used when multiple items are ordered from the same supplier and delivered in the same shipment

c. The P system can be used for inexpensive items for which records are not maintained. e.g. Bolts consumed in a manufacturing process . Bolts are filled in bins up to target at fixed intervals.

Q System(Probabilistic case)

In this model the quantity is withdrawn from the total stock to determine the quantity in hand. The reorder level is set corresponding to a minimum stock level. When this level is reached , a fixed quantity may be ordered . At the reorder point , the level of inventory equals the expected demand in lead time plus the safety stock to absorb the fluctuations in the change of demand and lead time.

5.4.3 2 - bin system.

Concept of safety stock, Determination of Safety stock for variation in consumption during lead time, variation in lead time Determination of service level based on cost optimization, Application of simulation in inventory control. An Inventory Management Simulation

NOTES

An important part of courses in quantitative methods is helping students gain an intuitive feeling for formulation structures and solution techniques. The Inventory Management Simulation (IMS) program is designed *to* allow students to manage a simulated inventory interactively. The computer generates random demands and keeps the inventory records for the student who selects and applies the appropriate inventory policy. The student thus experiences what he has learned from the equations and formulas in inventory theory. We also have found IMS to be an excellent bridge between the subjects of inventory models and simulation.

5.5 SUMMARY

Inventory (spares and consumables) are kept in main stores/Sub-stores. Inventory is in the form of working capital. Various inventory costs are as: Cost of capital is the opportunity cost of investing in stocks of inventory. Procurement cost is the costs associated with tendering, evaluation of bids, ordering and follow up, receipt and inspection of materials etc. Material handling cost is the cost of moving materials from one place to another place within the factory. Space cost can be considered as the rent paid to the cubic space occupied by inventory. Cost of administration includes the salary of staff, telephone/fax charges, postal/ courier expenses. Insurance costs are the costs associated with insurance coverage for the stock of materials.

Stocks of inventory are classified as A, B, and C items for selective management control. This is known as ABC analysis. There are various bases for ABC classification- price, weight, size, non-availability etc. ABC analysis is based on the annual consumption value of the items. Economic order quantity (EOQ) is that size of order which minimizes total annual cost of carrying inventory and the cost of ordering under the assumed conditions of certainty and those annual demands are known. If a company manufactures its component which is required for its main product, then the corresponding model of inventory is called "Manufacturing model". The rate of consumption of items is uniform throughout the year. The cost of production per unit is same irrespective of production lot size.

Check Your Progress

5. What the different models of inventory.
6. Write a short note on P and Q – system (deterministic case).

5.6 ANSWER TO "CHECK YOUR PROGRESS"

1. Inventory (spares and consumables) are kept in main stores/Sub-stores. Inventory is in the form of working capital.

Functions of inventory:

Any production process may have imbalances in the consumption of materials. Production rates may also be varying from stage to stage. Hence firms should keep minimum stocks of inventory.

Depending upon the consumption rates and lead times for purchase of the materials, inventories are kept in stores

2. Various inventory costs are:-

Cost of capital is an important cost. This is the opportunity cost of investing in stocks of inventory.

Procurement cost is the cost associated with tendering, evaluation of bids, ordering and follow up , receipt and inspection of materials etc

Material handling cost is the cost of moving materials from one place to another place with in the factory

Space cost can be considered as the rent paid to the cubic space occupied by inventory.

Cost of administration includes the salary of staff, telephone/fax charges, postal/ courier expenses

Insurance costs are the costs associated with insurance coverage for the stock of materials.

3. Stocks of inventory are classified as A, B, and C items for selective management control. This is known as ABC analysis. There are various bases for ABC classification- price, weight, size, non-availability etc. ABC analysis is based on the annual consumption value of the items.

Small number of items which account for a large proportion of the annual turnover (in money terms) can be classified as "A" items.

Large number of items which account for a small proportion of the annual turnover (in money terms) can be classified as "C" items.

The balance of items which may be of moderate quantity and value(in money terms) can be classified as "B " items.

Figure shows that 10% of the items ("A" items) contribute to about 75% of total consumption value of all materials in the inventory. 70% of the items("C" items) contribute to about 10% of total consumption value of all materials in the inventory and 20% of the items("B" items) contribute to about 15% of total consumption value of all materials in the inventory. ABC classification of the previous year may not necessarily hold good for this year.

Percentages mentioned here are only illustrative. It may vary from industry to industry . Classification of items as A or B or C may be reviewed from time to time(every one or 2 years).

A proper ABC analysis will lead to better control over materials and consequent reduction in costs.

4. Economic order quantity (EOQ*)* is that size of order which minimizes total annual cost of carrying inventory and the cost of ordering under the assumed conditions of certainty and that annual demand are known

5. The different models of inventory are:-

- Purchase model with instantaneous replenishment and without shortages.
- Purchase model with instantaneous replenishment and with shortages.
- Manufacturing model without shortages
- Manufacturing model with shortages

6. Q – System(Deterministic Case)

The stores manager places order for a batch quantity Q whenever the stock level reaches a prefixed level called Reorder level. In this model, the order batch quantity and the reorder level is fixed. This model is best suited when the demand for a product is fluctuating. The chance of shortage is less in this model.

The P – System(Deterministic Case)

In this model, Stores Manager places order for materials after reviewing the stock level at a fixed interval P. in this model, the maximum stock level is fixed at T. This model is suitable when a supplier provides a variety of items and the demand does not fluctuate.

5.8 FURTHER READING

- N. V. Reinfled, (1987) "Handbook of Production and Inventory Control" Englewood Cliffs, Prentice Hall.
- M. K. Starr and D. W. Miller, (1990) "Inventory Control: Theory and Practice", Englewood Cliffs, Prentice Hall.
- E. A. Silver, D. F. Pyke and R. Peterson, (1998) "Inventory Management and Production Planning and Scheduling", 3rd edition, New York: John Wiley.

NOTES

SIMULATION

6.1 Introduction to Simulation
6.2 The use of IMS in Simulation
6.3 Running the Simulation
6.3.1 Pedagogical Uses
6.3.2 Technical Information
6.4 Spares planning and control.
6.5 Summary
6.6 Answer to "Check Your Progress"
6.7 Further reading

6.1 INTRODUCTION TO SIMULATION

The purpose of simulation and gaming in the pedagogical setting is to give students the chance to apply theories and techniques learned in the classroom. In business oriented simulations, especially those involving quantitative techniques, it is often difficult to isolate the decision making process from the mechanics of the simulation. This is particularly true with inventory simulations because of the amount of bookkeeping required for inventory management. The Inventory Management Simulation (IMS), a computer based simulation, is designed to alleviate this problem. It acts both as customer and bookkeeper for the student. It generates demands, and maintains all the necessary records. The student is then free to focus on individual decisions and the decision making process. The interactive nature of the software makes the use of the simulation relatively unstructured, so the student can control the time and frequency of its use. The flexibility of the software allows the instructor to adapt it to a wide variety of learning situations

6.2 THE USE OF IMS IN SIMULATION

The IMS program may be used with any one or a combination of learning objectives in mind. One is to reinforce the basic concepts of inventory management such as EOQ, reorder level, lead times, and safety stock. Another is to reinforce the concepts of cost trade offs in inventory management by generating the cost curves. A third might be to teach the students about simu-

lation. Further objectives might be to reinforce concepts of statistics or random number generation. Methods of achieving these goals using IMS are explained later.

Valves compromise this simulated inventory in IMS. Any item would do, but to be realistic the item must exhibit the following characteristics:

(1) it must be low enough in cost to represent an insignificant proportion of the firm's invested capital, (2) demand per period must be in relatively small increments compared to, say, annual demand, **(3)** some demand will occur in virtually every period, and (4) demand should not be subject to periodicies, such as seasonal effects (trends are allowed, however). In a typical firm, these conditions will, in fact, hold for 80% or more of its inventory items. The primary type of items excluded by the conditions are high value items (such as jet aircraft) which are generally made to order anyway.

As with any simulation, the instructor or game administrator must set the initial conditions and the parameters that control the dynamics of the simulation. In the IMS, the parameters are set in the program itself. They are set in such a manner as to allow the instructor or administrator to change them easily. Regularly changing the parameters is not necessary, however, since the randomly generated demands and the instructor's directions to the students will be the primary influences on the particular results. The decision policy derived by the students through EOQ analysis is sensitive to the combination of parameters. The instructor, therefore, must exercise care in setting up the simulation. For example, setting ordering costs very high and holding costs very low might result in a student ordering one time during the simulation. The initial conditions and parameters (with typical values in parentheses) are

Units on hand at the beginning (140 units)

Unit cost ($15/unit)

Ordering cost ($Warder)

Holding cost ($0.4o/unit/period)

Stock out penalty cost ($4/unit/period)

Expedite cost ($0.50/unit/period) **(3** period maximum)

Mean demand *(20* unit period)

Mean ending period and maximum deviation **(20,** 5 periods)

Once the parameters are set, the simulation is ready for the students. One parameter that may not be changed without extensive reprogramming is

the four-period lead time estimated for orders to arrive. Before actually running the simulation, the student should devise his or her inventory management policy using the appropriate model and tlie instructor's directions (see below). Whatever the policy, the student must make the following decisions in each period:

- Whether or not to order
- How much to order
- How much to expedite

The computer software acts as customer and bookkeeper. In its role as customer, it generates a total demand for each period. Demands are generated from a Poisson distribution using Fishman's routine. The mean demand for the distribution is a parameter set previously by the instructor.

6.3 RUNNING THE SIMULATION

The transition from preparing to use IMS to actually running the simulation is seldom as smooth as may be implied here. Students need to be comfortable using the computer. In addition, we have found it useful to assign the students to do preliminary runs of IMS, the only goal being familiarity with the program. Many will still attempt, however, to carry out assigned exercises without preparation. The program is self-documented, so the students may request instructions each time. During any given period, the basic sequence of events is: any orders due in arrive at tlie beginning of the period and are added to inventory on hand, demand occurs in the middle of the period, and decisions are made at the end of the period. At the beginning of the simulation, of course, the student will have placed no orders, so the first event is demand. With the decision required at the end of the period, the student gets to see the generation of first period demand and the printing of the summary table before having to respond to the program. Since the lead time is four periods, the initial inventory must be set high enough to absorb four periods of demand (unless the instructor wishes to force the students into a stockout or expedite situation).

After the current period demand is generated and printed, the program prints a period summary table that recapitulates all the transactions that have taken place since the previous summary. Included in the summary are: number ordered at the end of the last period demand for the current period current inventory (including arriving orders and demand for the current ordering cost

for orders placed last period one period holding cost for current inventory the cost of expediting orders last period the penalty cost for unfilled demand in the previous period total cumulative cost to date number of units due during each of the next four periods The system treats unfilled demand as backorders and assesses a unit charge for each period the backorder is carried. Ordering cost is just the cost of placing the order; the actual cost of the units is added to total cost when they arrive. period)

The student makes the ordering and expediting decisions at the eqd of each period. Whether or not to order and how much to order will depend upon the instructor's directions and the policy worked out by the student. As an error check, the program only accepts orders for zero through 999 units. Once the student has placed an order, it will appear in the due-in schedule of the period summary until it arrives.

Expediting is a more complex decision. **If** the student decides to **expe**dite, the program prints out the present due-in schedule for the end of the next period. All expediting must be within that schedule. This means that no units may be expedited to arrive in the next period. Units may be expedited one, two, or three periods within the schedule. Only one expedite decision may be placed per period, however, and all the units expedited must come from the same due-in order, i.e., one may not expedite parts of two different orders. If more than one order (including any order just placed) is due-in, the order due-in the soonest will be expedited. There are two exceptions. **If** the closest due-in has insufficient units, the next due-in with sufficient units will be expedited. The second exception occurs when the order due-in the soonest may not be expedited the specified number of periods, i.e., it is due-in *too* soon. The program will skip down to the first eligible order. If the student orders an impossible expedite, the program will print an error message and recycle to

the "expedite or not" decision. This complex expediting system is intended to add an additional touch of realism to the simulation. Inventory managers may generally expedite orders. It is costly, however, since it involves extra handling and may require a more expensive transportation mode. Suppliers treat orders separately and generally would not accommodate an excessive reshuffling of orders in process: thus the limitations on the number of expedites per period and on splitting two or more orders. Not allowing students to expedite into the next period simulates an order enroute.

Once an order has been turned over to the transportation agent, all the manager can do is wait. The simulation ends randomly according to a uniform distribution. The mean ending period and the maximum deviation are initializing parameters set by the instructor. Ending the simulation randomly discourages the students from playing end-game strategies. Setting high stock out costs can also discourage such strategies. A summary at the end of the simulation tells the student the total cumulative cost for managing the inventory, mean cost per period, and the value of the ending inventory. The mean cost per period is the primary datum one should use in evaluating different management policies.

6.3.1 Pedagogical Uses

The IMS is flexible enough to perform a true simulation; that is, one may run the simulation using a number of different inventory management policies to compare the cost of operating under each policy. As it is presently written, the IMS offers flexibility primarily in ordering frequency and the treatment of safety stock. This allows the instructor to devise scenarios comparing the costs of continuous review and periodic systems as well as systems involving various amounts of safety stock (including no safety stock). The flexibility of IMS also allows the instructor to use it to reinforce learning at all phases of instruction in inventory systems.

One of the first concepts the instructor must teach is that inventory management is an unconstrained optimization problem requiring tradeoffs between ordering and holding costs. An analysis of the tradeoffs results in a total cost curve as the one in Fig. 1. The students' intuitive understanding of the tradeoffs may be reinforced by assigning them to empirically generate the cost curve using IMS. The instructor would assign the students to run IMS successively starting with one order in period one large enough to last for the entire simulation (minimum order cost and maximum holding cost) and increasing the number of orders by one for each run until the last run had one order per period (minimum holding cost and maximum order cost). All orders in any given run should be the same size. The students may use the resulting data to plot the cost curves. They may also use the graphs later in the course to aid in evaluating an actual simulation. By running a formal simulation, the students not only gain insights into the relative costs of various inventory management policies, but also create what is essentially a living case to use when they study simulation. In a typical use, the instructor might compile a list of, say, five basic inventory management policies:

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- continuous review with safety stock
- continuous review without safety stock
- periodic review with safety stock
- periodic review without safety stock
- intuition

Within these rules, the instructor must decide how much latitude to give the students in computing safety stock levels, and what period should be used for the periodic review. One must take care to insure both that the period chosen is significantly different from the natural period in the continuous review models, and that initial inventory is sufficient. To obtain the data from the simulation, the instructor may either divide the class into five groups and assign one strategy to each group (each student in the group would run the simulation several times using the assigned decision rule), or each student may be assigned to run the simulation five times (once with each rule). We prefer the latter approach since repetitions using the same decision rule breeds boredom and encourages errors or self-induced "variations." Allowing the students to run IMS using the intuition strategy gives them an outlet for their natural tendency to try and "beat the system." Most find the system ends up beating them.

The results from the individual runs may be compiled in class. The instructor or the students may compute the mean, standard deviation, and any other desired statistics for each management strategy. The students normally enjoy comparing demand patternsl and other aspects of the simulation. The instructor may use these openings as opportunities to discuss fine points of the Poisson distribution, simulation techniques, statistics, or inventory management. At this point, the students feel as if they have "experience" in managing inventory, and enjoy sharing their experiences.

The primary pedagogical problems in using IMS are the students **(1)** "tinkering" with the decision rules (usually unsuccessfully), **(2)** playing endgame strategies (usually unsuccessfully), and **(3)** engaging in leastcost competition with other students. Since IMS runs interactively at little cost, one may usually insist upon the students sticking to the rules for the assigned runs, and then allow them to run the system as often as they like beyond that. To encourage serious thohght ahead of time about strategies and decision rules, we have disabled the ability to abort the program. Once a student has began a run, he must finish it, careless errors or misguided strategies notwithstanding.

(This feature is easily removed if the instructor wishes.) The random endpoint also discourages endgame strategies

NOTES

6.3.2 Technical Information

IMS was programmed in DEC BASIC-Plus running under RSTSJE, version 6A. A version in DEC-10 BASIC running under TOPS-10 is also available. Since the program runs in less than 8K and uses only core arrays, with minor modifications it will run on most interactive systems using BASIC. The program has been written as a series of subroutines for ease in making desired modifications. Student instructions are contained in the program itself.

In addition to the variations in IMS possible by changing the parameters, several modifications are possible with a minimum of programming. One variation is to treat stockout situations as lost sales instead of backorders. Total inventory would never fall below zero, and a one time penalty cost would be charged each time a unit was demanded but was not available. The penalty cost should be set high enough relative to ordering and holding cost to discourage running out.

Another possible variation is to have mean demand change. One may devise simple patches to cause mean demand to change by a constant amount or according to a specified functional relationship. This forces students to pay attention to trends in demand, and gives the instructor an additional opportunity to introduce or relate the appropriate statistical techniques.

Other possible variations are to randomize lead times, to allow quantity discounts on orders, or to eliminate the expedite option, The flexibility and ease of changing IMS gives the instructor the options of either tailoring a simulation to meet his needs exactly, or creating a series of programs, each with different features. The purpose of the IMS program is to give the student in a quantitative methods, production management, or similar course the opportunity to experience, as well as to study, the operation and results of optimal (and non optimal) inventory policies. The interactive nature of the simulation gives the student rapid feedback and results, and heightens the realism of the simulation. Having the computer play the role of bookkeeper forces the student to focus on the decision making process. If the **ude** of IMS precedes the study of simulation techniques, it provides a case study of a simulation. The students, however, are a part of the case study. They have experienced the results, and may now analyze the mechanics and techniques of the simulation and the methods of evaluating the results. We have used IMS without

alteration for approximately four years in quantitative methods and production management courses with numerous textbooks [e.g., 4.53 and course outlines. We have been pleased with the results, and students have always reacted with enthusiasm. IMS has exceeded our expectations as a teaching device. By confronting students with the necessity for translating abstract formulas and concepts into concrete action, the simulation reinforces concepts such as EOQ, reorder level, and safety stock, In one test of leatning effectiveness, two groups of students in an operations management course were given the identical exposure to inventory management except that one group ran IMS and the other did not. Both groups were given a multiple choice exam which included five basic knowledge questions on independent demand inventory systems.

The group using IMS scored a mean of 4.23 (S=1.23) out of **5** correct and the group not using IMS scored a mean of 2.89 **(S=1.37)** out of **5** correct. The difference between the means is significant at the 0.0006 level.

NOTES

Check Your Progress

1. Define Simulation.
2. What is the use of IMS in Simulation?
3. Explain running of Simulation.

6.4 SPARES PLANNING AND CONTROL.

Introduction

Many industries depend on the availability of high-value capital assets to provide their services or to manufacture their products. Companies in these industries use capital assets in their primary processes and hence downtime can among others result in (i) lost revenues (e.g. standstill of machines in a production environment), (ii) customer dissatisfaction and possible associated claims (e.g. for airlines and public transportation) or (iii) public safety hazard (e.g. military settings and power plants). Usually the consequences of downtime are very costly.

A substantial group of companies in these industries both use and maintain their own high value capital assets. Examples include airlines, job shops and military organizations. Within these companies, a Maintenance Organization (MO) is responsible for maintaining the capital assets. Besides maintenance activities, supply and planning of resources, such as technicians, tools and spare parts, are required. A Maintenance Logistics Organization (MLO) is responsible for matching the supply and demand of the spare parts required to conduct maintenance.

Characterization of the environment

In the primary processes of the companies we consider, a substantial set of capital assets (asset base) is used for multiple purposes. Because of strate-

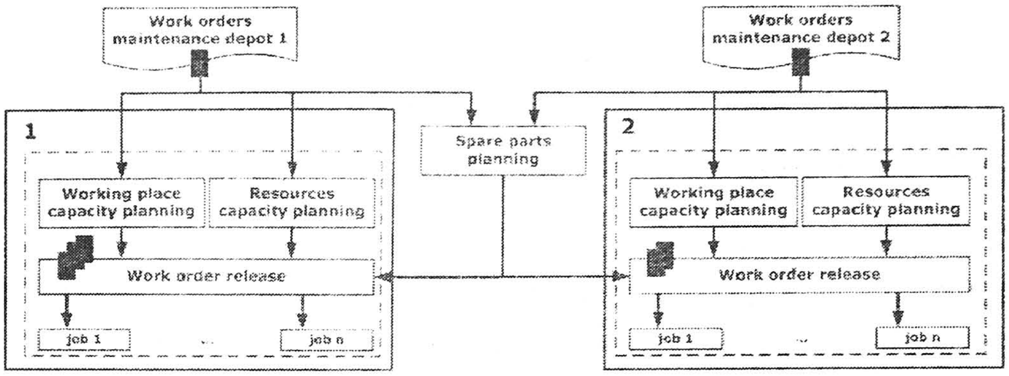
gic decisions, new systems phase in and rejected systems phase out of the asset base. Maintaining this set of assets is an important task because downtime of assets immediately affects the primary processes. A capital asset is (partially) operational in case it is available for (a part of) all use purposes and a capital asset is down whenever it is in maintenance or waiting for maintenance to be conducted. Maintenance is either planned or unplanned and it is conducted within the constraints of the maintenance policy/concept. To reduce the time an asset spends in maintenance it is common practice to maintain parts of the asset rather than the asset itself. When an asset is maintained, parts that require maintenance are taken out and replaced by Ready-For-Use (RFU) parts. Spare parts used at the first level maintenance are also called Line Replaceable Units (LRU's) (Muckstadt, 1973, 2005). The decision to designate a part as a LRU lies with the maintenance organization. LRU's that are taken out are either scrapped or sent to a repair shop for repair. Repaired parts are sent back to a ready-for-use LRU stocking location where they can be used again to replace a part. This principle is called 'repair-by-replacement' (Muckstadt, 2005) and makes the control of the spare parts supply chain a paramount task for the MLO.

MLO's try to find the optimal balance between spare parts availability, working capital and operational costs, within their span of control. Several tasks need to be conducted and decisions need to be taken in order to achieve the desired spare parts availability, possibly under constraints of working capital and/or operational costs. In this section, an outline is given of the environment in which MLO's operate. First we characterize the process of maintaining the capital assets, second we discuss the spare parts supply chain and we end with the characterization of spare parts demand.

Characterization of system maintenance

The MO's we consider maintain a set of several high-value capital assets. The asset base is sufficiently large to generate a reasonably constant demand for maintenance activities. Examples of such asset bases include eets of airplanes/trains or manufacturing equipment in a reasonably sized job shop. Maintenance on a capital asset is conducted according to a maintenance policy, maintenance program, maintenance planning or a modification plan. We distinguish three types of maintenance

Figure 1: Hierarchical planning framework for maintenance of high-value capital assets.



Preventive maintenance: maintenance that is conducted in order to prevent failure. Usually this maintenance is planned some time in advance and has to be conducted within a registered time frame during which the asset is in non-operating condition. Within this registered time frame, rescheduling of maintenance tasks is often possible. In some cases inspection can be separated in time from replacements to enable better resource and spare parts planning.

Maintenance delay enlarges the time during which the asset is in non-operating condition and hence decreases the operational availability of the asset.

Corrective maintenance: maintenance that is conducted after a failure has occurred. Corrective maintenance can be partially planned when it involves a non-critical part whose maintenance can be delayed after failure, but usually it is unplanned due to unforeseen breakdown of parts. When this happens maintenance needs to be conducted immediately as maintenance delay decreases operational availability of the asset.

Modificative maintenance: maintenance conducted to improve the performance of the capital asset. This maintenance can be delayed until all resources are available.

Maintenance spare parts supply chain overview

We consider organizations in which the supply chain already exists, i.e. location and size of warehouses are predetermined. The spare parts supply chain is in general a multi-echelon system. We distinguish two types of spare parts:

1. Repairable parts: parts that are repaired rather than procured, i.e. parts that are technically and economically repairable. After repair the part becomes ready-for-use again.

2. Non-repairable parts or consumables: parts which are scrapped after replacement. Consumable LRU's need to be replenished from outside suppliers, whereas repairable LRU's are sent to a repair shop. The LRU is repaired at the repair shop and usually one or more parts in the LRU are replaced.

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Parts that are replaced in the repair shop rather than at first level maintenance are called Shop Replaceable Units (SRU's). SRU's, like LRU's, can either be consumable or repairable and need to be replenished from external suppliers/ repair shops or an internal repair shop, respectively. Hence there are multiple levels of repair.

In general there are multiple first level maintenance sites with associated spare part stocks. In general the spare parts supply chain is a multi-echelon divergent supply chain with multiple repair shops. Additionally, the supply chain has closed-loops for repairable spare parts. When demand for a LRU cannot be met from local stock, emergency procedures such as lateral transshipments or emergency shipments from upstream stocking locations may be applied.

Figure 2 presents a typical example of a spare parts supply chain within companies that both use and maintain high value capital assets. A central stocking point of spare parts supplies several local stocking points that are incident to the first level maintenance sites. There is also a stocking point of parts that still need to go to repair and a stocking point of parts required for new projects and modifications that occur during the life cycle of a capital asset. In practice these stocking points are often in one and the same warehouse, but for control reasons these stocks are distinguished.

Maintenance spare parts demand characteristics

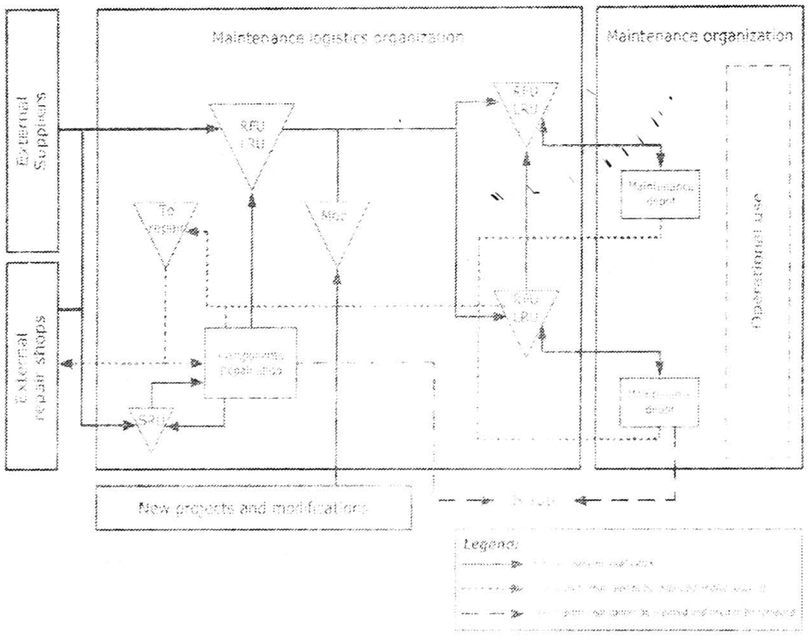

Figure 2: Example of a maintenance spare parts supply chain

As mentioned in the Section 2.1, maintenance on a capital asset generates demand for LRU's. The MO requests the required LRU's at the MLO by creating spare parts orders, related to a work order. The LRU's are delivered

from the stocking location incident to the requesting maintenance depot. If not enough LRU's are available, then parts are delivered from the central stocking location or possibly via transshipment from a different stocking location. Each type of maintenance on the capital assets generates demand for LRU's in a difierent way.

MO's create work orders for preventive and modificative system maintenance some time before the desired start of the work order. When the work order is created, the spare parts requirements are known and fixed. The required LRU's to conduct the maintenance are requested by the MO with a desired lead time, i.e. delivery lead time. The desired delivery date for an LRU need not necessarily be equal to the start date of the work order, as not all maintenance tasks (including their required LRU's) commence simultaneously with the start of the work order. It is possible that the desired delivery dates of LRU's change over time as maintenance tasks are rescheduled. Work orders for corrective maintenance are created after the probable cause(s) of breakdown is (are) diagnosed. The MO updates the work order planning and orders the required spare parts at the MLO. The desired delivery date for an LRU is then equal to the start date of the work order. Typically, maintenance depots and MLO's make agreements on specified upper/lower bounds for key performance indicators such as (i) the average work order delay due to unavailability of spare parts, (ii) the percentage of work orders without delay (caused by unavailability of spare parts) or (iii) the maximum \number of unfinished work orders" due to unavailability of spare parts at any given time. Separate agreements are made on the availability of spare parts that do not cause immediate system downtime.

Framework for maintenance spare parts planning and control

In this section we present the framework for maintenance spare parts planning and control. In Figure 3 an overview and clustering of the main tasks and decisions in MLO's is presented, including their mutual connections. We separate eight different processes, which are numbered one up to eight in the figure. Within each process, we distinguish different decision levels. Decisions that are not made very frequently, i.e. once a year, are marked 'S/T' (strategic/tactical decisions); decisions made regularly, i.e. once a month or quarter, are marked 'T' (tactical decisions) and decisions made frequently, i.e. once a day/week, are marked 'O' (operational decisions).

An arc illustrates that information, e.g. data or outcome of decisions, flows from one process to another. This information is needed to make deci-

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sions in subsequent processes. We emphasize that there are many feedback loops between the various processes. For example, a feedback loop occurs when input from demand forecasting and supply structure management lead to unusually high inventory levels and demand forecasts and/or supply structures are reconsidered. For readability these feedback loops are left out of the figure.

We recall that the framework we provide will need refinement and alterations for every particular organization. The framework does serve as a useful starting point in making specific designs of maintenance spare part planning and control systems. In the remainder of this section we outline each cluster of decisions from the perspective of the performance indicators MLO's face.

Assortment management

Assortment management is concerned with the decision to include a spare part in the assortment and maintaining technical information of the included spare parts. We emphasize that the decision whether or not to include a part in the assortment is independent of the decision to stock the part. The process of managing the assortment can be found in Figure 4.

Spare parts assortment

The decision whether to include a part in the assortment is usually taken shortly after procurement (initial phase) of a (sub)system. There are two options when to include a part in the assortment: before or after the first need for the part. In case a part is included in the assortment, then there is a possibility that the part is never needed during its lifecycle. Time spent on collecting information, signing contracts with potential suppliers on unit price and (contractual) lead and/or repair times and adding the part to the database has been done without any use, which results in unnecessary operational costs. However, in case a part is not included in the assortment there are two possible adverse consequences. First, when the part fails and a supplier is still available, the lead time of the part is higher due to data collection and negotiation actions. Second, when the part is needed there may not exist any suppliers for it anymore. In this case, the part may have to be custom made. To do this, in many cases specialized technical information regarding the form, fit and function is needed. If a part is not included in the assortment this information is not available. A trade-ofi should be made between cost of including the part in the assortment and the expected cost of extra downtime, e.g. based on the probability that the parts will be needed in the future and a simple failure

mode efiects and criticality analysis.

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Gather parts (technical) information

Once a part is included in the assortment, (technical) information of the part is gathered and maintained. The MLO needs to decide whether or not to gather and maintain parts technical information that is important for spare parts planning and control: (i) criticality, (ii) redundancy, (iii) commonality, (iv) specificity, (v) substitution, (vi) shelf life, (vii) position in the configuration1 and (viii) repairability. Additionally technical information regarding form fit and function may be gathered. We also distinguish so called 'insurance' spare parts.

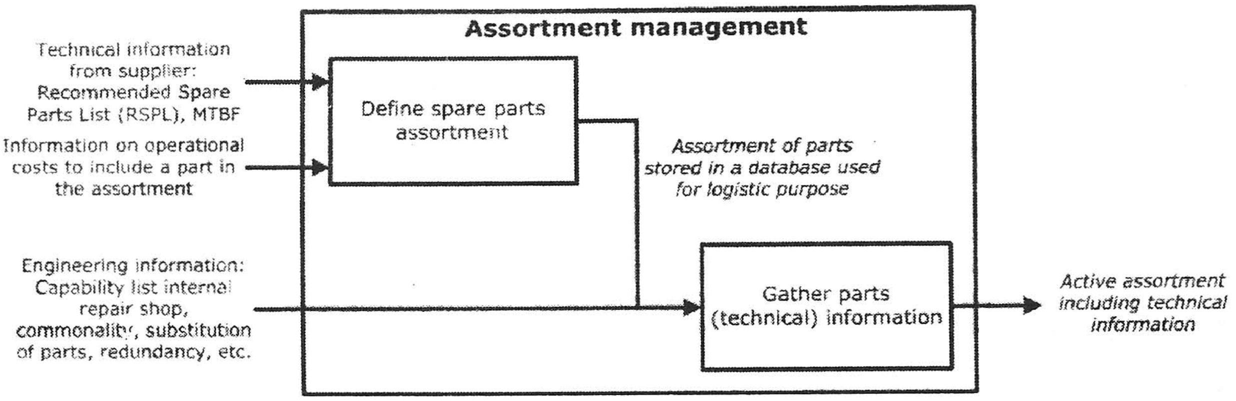

Figure 4: Process of managing a spare parts assortment.

Parts criticality is concerned with the consequence of a part failure, that is the type of breakdown and reaction time. We distinguish two types of system breakdown, i.e. full or partial system breakdown. Full system breakdown means that the system is non-operational for all assigned use purposes. Parts that cause full system breakdown are denoted critical. Partial system breakdown means that the system is operational for only a part of the assigned use purposes. Parts that cause partial system breakdowns are denoted partially critical. Parts that cause no system breakdown, i.e. the system can be used for all assigned use purposes, are denoted 'non-critical'. Parts redundancy is the duplication of system components (parts) with the intention to increase the reliability of the system. The decision to duplicate parts is either made by the OEM or the MO. Information on parts redundancy decreases the number of stocked spare parts as it is known in advance that part failure does not cause immediate system breakdown. Hence stock levels for redundant parts may be decreased. Parts commonality concerns parts that occur in the configuration of multiple systems that are maintained by the MO. For each system the MLO's needs to meet a certain service level.

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Information on parts commonality is needed for customer (system) service differentiation in spare parts planning as well as for the decision where to stock parts, i.e. locally or centrally. The specificity of a part concerns the extent to which a part is tailored for and used by a customer. Parts availability at suppliers is usually low, if not zero, for specific parts and hence this might effect the size of the buffer stock needed. Parts are substitutional in case different parts have the same form, fit and function. This means that requests for one part can be met by a substitute part. Information on parts substitution is used to prevent stocking parts for which requests can also be met by a substitute part. The shelf life of a part is the recommended time period during which products can be stored and the quality of the parts remains acceptable for usage. This information is used to prevent stocking to many parts that are scrapped or revised after the shelf life of the part has expired.

The configuration is a list of raw materials, sub-components, components, parts and the quantities of each that are currently in a system. Hence this list contains all the SRU's and LRU's in the system that may require maintenance during its use. The position of a part in the configuration is needed to determine at which level parts (SRU's) can be replaced, in order to repair an LRU, and what quantity of each SRU is needed. These different levels in the configuration are also called indenture levels. The initial configuration is usually provided by or available at the OEM and coincides with the bill of materials.

Parts reparability concerns the identification whether a part is technically repairable and if so, whether or not the internal repair shop has the authorization (from the OEM) and the capability to repair the part. This information is needed to determine the parts supply structure.

Technical information on form, fit and function comes in many forms depending on the technological nature of the part involved. Sometimes this information is of a sensitive nature and the OEM may charge extra for this information and/or requires non-disclosure type contracts. 'Insurance' spare parts are parts that are very reliable, highly 'critical' to system availability and not readily available in case of failure. Often these parts are far more expensive to procure after the initial buy of the system, compared to buying at the moment of initial system purchase.

Because of their high reliability, these spare parts often will not be used during the lifetime of the system. Example of an 'insurance' part is a propeller in a ship. Parts (technical) information is sometimes provided by the OEM.

However, it is also possible that the MLO needs to determine this technical information. All the technical information is used to decrease the stock value or manage supply risk. For parts that are relatively cheap and well available at suppliers, spending time on collecting and maintaining technical information is not beneficial from a cost perspective. On the other hand, for parts that are relatively expensive or not well available at suppliers, gathering parts technical information is beneficial to control supply risks and operational costs.

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1.5 SUMMARY

The purpose of simulation and gaming in the pedagogical setting is to give students the chance to apply theories and techniques learned in the classroom. In business oriented simulations, especially those involving quantitative techniques, it is often difficult to isolate the decision making process from the mechanics of the simulation. The Inventory Management Simulation (IMS), a computer based simulation, is designed to alleviate this problem. It acts both as customer and bookkeeper for the student. The IMS program may be used with any one or a combination of learning objectives in mind. One is to reinforce the basic concepts of inventory management such as EOQ, reorder level, lead times, and safety stock. Another is to reinforce the concepts of cost tradeoffs in inventory management by generating the cost curves.

The transition from preparing to use IMS to actually running the simulation is seldom as smooth as may be implied here. Students need to be comfortable using the computer. In addition, we have found it useful to assign the students to do preliminary runs of IMS, the only goal being familiarity with the program. Many will still attempt, however, to carry out assigned exercises without preparation. The program is self-documented, so the students may request instructions each time. The IMS is flexible enough to perform a true simulation; that is, one may run the simulation using a number of different inventory management policies to compare the cost of operating under each policy. Many industries depend on the availability of high-value capital assets to provide their services or to manufacture their products.

> **Check Your Progress**
>
> 4. Define Spare parts assortment.
> 5. What are the characteristics of system maintenance?

6.6 ANSWER TO "CHECK YOUR PROGRESS"

1. The purpose of simulation and gaming in the pedagogical setting is to give students the chance to apply theories and techniques learned in the classroom. In business oriented simulations, especially those involving quantitative techniques, it is often difficult to isolate the decision making process from the mechanics of the simulation. This is particularly true with inventory simulations because of the amount of bookkeeping required for inventory management.

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2. The Inventory Management Simulation (IMS), a computer based simulation, is designed to alleviate this problem. It acts both as customer and bookkeeper for the student. It generates demands, and maintains all the necessary records. The student is then free to focus on individual decisions and the decision making process.
3. The transition from preparing to use IMS to actually running the simulation is seldom as smooth as may be implied here. Students need to be comfortable using the computer. In addition, we have found it useful to assign the students to do preliminary runs of IMS, the only goal being familiarity with the program. Many will still attempt, however, to carry out assigned exercises without preparation. The program is self-documented, so the students may request instructions each time. During any given period, the basic sequence of events is: any orders due in arrive at the beginning of the period and are added to inventory on hand, demand occurs in the middle of the period, and decisions are made at the end of the period. At the beginning of the simulation, of course, the student will have placed no orders, so the first event is demand. With the decision required at the end of the period, the student gets to see the generation of first period demand and the printing of the summary table before having to respond to the program. Since the lead time is four periods, the initial inventory must be set high enough to absorb four periods of demand (unless the instructor wishes to force the students into a stock out or expedite situation).
4. The decision whether to include a part in the assortment is usually taken shortly after procurement (initial phase) of a (sub)system. There are two options when to include a part in the assortment: before or after the first need for the part. In case a part is included in the assortment, then there is a possibility that the part is never needed during its lifecycle. Time spent on collecting information, signing contracts with potential suppliers on unit price and (contractual) lead and/or repair times and adding the part to the database has been done without any use, which results in unnecessary operational costs. However, in case a part is not included in the assortment there are two possible adverse consequences. First, when the part fails and a supplier is still available, the lead time of the part is higher due to data collection and negotiation actions. Second, when the part is needed there may not exist any suppliers for it anymore. In this case, the part may have to be custom made. To do this, in many cases specialized technical information regarding the form, fit and function is needed. If a part is not included in the assortment

this information is not available. A trade-off should be made between cost of including the part in the assortment and the expected cost of extra downtime, e.g. based on the probability that the parts will be needed in the future and a simple failure mode effects and criticality analysis.

5. The MO's we consider maintain a set of several high-value capital assets. The asset base is sufficiently large to generate a reasonably constant demand for maintenance activities. Examples of such asset bases include eets of airplanes/trains or manufacturing equipment in a reasonably sized job shop. Maintenance on a capital asset is conducted according to a maintenance policy, maintenance program, maintenance planning or a modification plan. We distinguish three types of maintenance Preventive maintenance: maintenance that is conducted in order to prevent failure. Usually this maintenance is planned some time in advance and has to be conducted within a registered time frame during which the asset is in non-operating condition. Within this registered time frame, rescheduling of maintenance tasks is often possible. In some cases inspection can be separated in time from replacements to enable better resource and spare parts planning.

Maintenance delay enlarges the time during which the asset is in non-operating condition and hence decreases the operational availability of the asset. Corrective maintenance: maintenance that is conducted after a failure has occurred. Corrective maintenance can be partially planned when it involves a non-critical part whose maintenance can be delayed after failure, but usually it is unplanned due to unforeseen breakdown of parts. When this happens maintenance needs to be conducted immediately as maintenance delay decreases operational availability of the asset.

Modificative maintenance: maintenance conducted to improve the performance of the capital asset. This maintenance can be delayed until all resources are available.

6.7 FURTHER READING

- G. Gordon, (1987) "System Simulation" 2nd edition, New Delhi: Prentice Hall India.
- R. E. Shannon, (1975) "System Simulation: The Art and Science", Upper Saddle River, NJ: Prentice Hall Inc.
- R. E. Nance and R. G. Sargent, (2002) "Perespectives of the Evolution of Simulation", Operations Research, Vol. 50 (1), pp. 161-172.

CHAPTER 7

STORES MANAGEMENT

NOTES

7.1 Introduction

- 7.1.1 Objectives of stores management
- 7.1.2 Functions of store keeper

7.2 Preservation of Materials in Stores

7.3 Storage system

7.4 Measurement of stores efficiency

7.5 Summary

7.6 Answers to "Check Your Progress"

7.7 Further Reading

7.1 INTRODUCTION

Store occupies an important place in the operations of business or industrial establishment. It provides continuous service to the manufacturing divisions. Stores management ensures:

- That the required material never goes out of stock;
- That no material is available in (much) excess than required
- To purchase materials on the principle of economic order quantity (EOQ), so that the associate d costs can be minimized
- To protect stores against damage, theft, etc.,

This can be achieved by the following:

- A proper purchasing practice (i.e.) when to order materials
- An adequate procedure of receipt and issue of materials
- Proper methods of storing materials.
- An effective system of physical control of materials.
- A proper method of keeping store records.

Store keeping is primarily a service function in which the store keeper acts as a custodian of all items carried in the store. Store keeping may be defined as a function of receiving, storing and issue of raw materials, bought out parts and components, spare parts, tools, consumables, stationary items to the user departments which have indented for the same. It is the aspects of

material control concerned with the physical storage of materials and goods.

Stores are mainly classified as i) Raw materials stores, ii) Component stores iii) consumable materials stores iv) Spare parts stores v) Maintenance materials stores vi) Scrap or disposal stores (Scrap yard)

7.1.1 Objectives of Stores Management

- To facilitate a balance and smooth flow of raw materials, components, tools and any other items necessary to meet production requirements.
- To maintain optimum stock of materials to compensate for irregular supplies by suppliers.
- To provide codification of stored items for easy recognition
- To facilitate quantity purchases at discount prices.
- To maintain record of all incoming materials and issue of materials to user departments.

7.1.2 Functions of Store Keeper

The store keeper occupies an important place in an organization. He is a person who has the control of activities to run a store in an effective manner. He keeps the material in systematic order according to the convenience of usage, requirements and handling. He should have sound knowledge of various materials used in an organization with their respective name, code and specification. He is the person who maintains the store with relative aspects that should not damage any material, men and machine (production). The following functions are considered to be a duty of store keeper:

- To receive raw materials, components, tools, equipments and other items required for day to day operation of an organization with proper accounting system of each material.
- To provide adequate space for storage and preservation of various kinds of materials in such a way that minimum loss of time to handle and verify the materials.
- To meet the demands of the user departments by proper way of issue and maintain the record of usability.
- To minimize obsolescence, surplus and scrap through proper codification, preservation and handling.
- To maintain the accumulation of stock, discrepancies and abnormal consumption in an effective and efficient manner.

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- To ensure good house keeping facilitating proper material handling, preservation, receipts and issues of materials.
- To harmonize material department in stock verification and provide supporting information for effective purchasing.

7.2 Preservation of Materials in Stores

Materials should be protected from ill-effects of humidity, sunlight, dust as well as biological and chemical agents. There are few rules for preservation of materials, such as:

- They should be kept on raised platforms; this prevents moisture from ground, dust, insects to spoil materials.
- The materials those with a limited lifetime should be issued on FIFO basis.
- A careful record of expiry date is desirable.
- Easy identification of materials and usage of materials should be known clearly.
- Optimum spaces, lighting and ventilation should be provided.

Preservation of specific materials:

Metals should be painted with oil or grease or covered with mineral jelly. Cast iron surface should be protected by bituminous paint. Wood should be painted with creosote oil to protect it from insects. Textiles are prone to be attacked by wooly bear and moth; these are protected with naphthalene balls. Rubber goods tend to harden with time and crack. They should be issued on FIFO basis. Chemicals should be stored in a cool, dry place and corked properly. Paints should be protected from fire and paint drums should be rolled periodically to prevent sedimentation. Measuring instruments, gauges and tools should be protected from rust by covering with application of a plastic compound which covers them on solidification.

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1. PRESERVATION MANAGEMENT:

Implements established standards and practices in the preservation field (AAM, AIC-BPG, AIC-PMG, ANSI, ASTM, ISO, SAA, ALA) by facilitating multiple functions (reformatting, environmental controls, collections maintenance, conservation treatment, conservation research, and preservation education). Assures responsible accessibility of collections material, i.e. determines level of accessibility appropriate relative to the preservation needs of the collection. Serves as a resource center or clearing house for information.

Functional Options:

a) assessment of short and long term preservation and resource needs for reformatting, environment, maintenance, treatment, research, and education.

b) policy formulation, dissemination, implementation.

c) guideline and procedures formulation, dissemination, implementation.

d) establishment of internal and external advisory groups.

e) designation of inhouse and off-site resources (i.e. storage, contracts).

f) on-going monitoring, evaluation and revision of all policies, options, etc.

Resources (products):

a) conservation assessment and preservation priority surveys.

b) coordinated policies to increase efficiency and cost-effectiveness.

c) manuals to enhance staff performance.

d) maintenance of currency in preservation.

2. REFORMATTING/
DUPLICATION:

Administrating appropriate reformatting options requires first evaluating special and general collections based on objective selection criteria (i.e. whether a collection constitutes high, medium or low value, use or risk, etc). Once evaluated, the collection can be matched to the most appropriate reformatting option (based on high, medium or low cost, time, personnel, quality or other factors). Once a collection is reformatted, the master, master copy, and user copies must be stored using appropriate options (outlined under environment below).

Functional Options:

a) preservation photocopying

b) preservation photo/negative duplication

c) preservation microfilming

d) digitization

e) motion picture transfer

f) audio transfer

g) other moderate risk collections if a moderate cost, time, and specialized process of moderate quality is appropriate.

Resources (selection criteria):

a) photocopying for low value, use and risk collections if a low cost, fast, easy copy of lesser quality is appropriate.

b) photo duplicate for high value, use and risk collections if a moderate cost, time, and specialized process of high quality is appropriate.

c) microfilm for moderate value, high use and

d) digitize for high value, use and risk collections if a high cost, moderate time, and highly specialized process for high quality, flexibility and accessibility is appropriate

3. ENVIRONMENT FOR STORAGE AND USE:

Environmental factors include facility and climate control (i.e. exposure to high, medium or low levels of light, temperature, relative humidity, pollution and pests, etc.); furniture (horizontal or verti-

Functional Options (for storage):

a) storage temperatures
-cold
-cool
-ambient/temperate

b) storage relative humidity
-low

Resources (use)

a) special collections, master copies.

b) user copies and general collections.

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cal storage on open or closed shelves, drawers); containers (individualized or bulk storage in vertical, horizontal or rolled orientation); and housing (paper, polyester film), among other things (such as accessibility and controls for handling and disaster control including integrated pest management). Each of these factors consist of options that can be matched to master collections (specialized or general), master copies, and user copies. If appropriate environmental and storage procedures are followed, the first steps toward integrated pest management (IPM) and other disaster prevention functions is assured. Disaster prevention includes proper building maintenance, environment and handling practices, as well as IPM and disaster response and recovery plans.	-moderate c) furniture (must consider materials and technique of structure, movable or stationary, etc.) -open shelves -closed shelves -drawers d) containers -vertical or horizontal boxes (buffered or neutral record unit, document, clam-shell, phase, adjustable, or solander boxes, etc.) -folders -tubs -canisters e) housing (vertical, horizontal, or rolled orientation) -paper folders, wraps, mats, etc. -polyester folders, pockets, wraps, etc.	
4. COLLECTION MAINTENANCE: Preventive conservation care activity including assessing and monitoring of environmental climate, storage, exhibition, IPM; light cleaning, flattening, fastener replacement, and rehousing to stabilize, support and enhance accessibility of collections; co-ordination of supply purchases, etc.	**Functional Options:** a) assessing and monitoring of environmental climate, storage, exhibition, IPM. b) light cleaning, flattening, fastener replacement, and rehousing to stabilize, support and enhance accessibility of collections. c) spot testing and humidification of rolled materials. d) co-ordination of supply purchases, etc. e) upgrading of supplies. f) upgrading of procedural manuals.	**Resources (needs and products):** a) supplies and equipment. b) accessible collections. c) reduction in cost of interventive conservation treatment.
5. CONSERVATION TREATMENT: Interventive conservation care to chemically and physically stabilize carefully selected individual or batches of	**Functional Options:** a) conduct condition assessments with treatment recommendations. b) consult on treatment priorities, options, time tables.	Resources (products): a) collections stabilized at an appropriate level of care. b) a phased approach to care composed of discrete but interrelated phases to maximize

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jeopardized, fragile, disfigured, or rapidly deteriorating materials (i.e. with biological infestation, acidic staining tapes and brittle mounts collections material) in order to facilitate accessibility for use, reformatting, exhibition, loans, etc.	personnel. c) advise on the effects of exhibits and loans. d) advise on material stability. e) select, develop and implement treatment protocols. f) train collections maintenance staff.	minimum resources similar to a triage method. c) improved accessibility of collections to users. d) enhanced research value.
6. CONSERVATION RESEARCH: To insure that all the above functions represent the optimum level of care, as well as to aid staff and users in extracting optimum information from collections materials (for historical, social, cultural, etc. research), requires research on materials characterization, technologies of production and use, deterioration mechanisms, and both short and long-term preventive and interventive conservation care procedures. Conservation research leads to theories and models forming the bases for guidelines that then are enacted as practical measures; these measures are then monitored, tested, evaluated, and modified by conservation research to formulate improved theories and models.	**Functional options:** a) characterization of materials, their technologies, and deterioration mechanisms. b) evaluation of impact of handling and environmental issues. c) testing and development of preventive conservation care maintenance and interventive conservation care treatment measures. d) development of standards and testing procedures and equipment.	**Resources (products):** a) care of archival collections (paper-base, photo, film, magnetic and electronic media). b) testing of storage materials. c) care of modern materials. d) development of evaluation of care and treatment protocols.
7. PRESERVATION TRAINING: In order to comply with established standards and practices for the care of collections outlined in all the functions above, all staff and users need systematic and ongoing short- and long-term theoretical and practical training.	**Functional options:** a) preservation management. b) identification, nature/characterization, and deterioration of materials. c) handling. d) environment, storage, exhibition, transport. e) disaster prevention, preparation, response and recovery. f) collections maintenance. g) conservation priorities and practices. h) long-term research, regular analysis and monitoring of stability, maintenance and testing of collection standards, and development of research plans. i) publication and dissemination of all of the above.	**Resources (audiences):** a) inhouse staff (collections managers, curators, librarians, archivists, exhibits staff, specialists, technicians, etc.) for practical training and career development. b) users (handling, nature of materials, etc.) c) allied agencies and professionals.

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7.3 Storage system

In industrial engineering, the internal arrangement of a store is known as Layout. **It is also called as "Work system design". Stores layout is a fundamental factor in determining the efficient performance of the stores department. An optimum utilization of stores should neither back the furniture too closely nor too. A well planned layout of a store makes the storage work easy. The receipt and issue of store material becomes** easy **and convenient. It gives better appearance to the stores and reduces the chances of damages, wastage and accidents. The following factors deserve serious consideration, while planning for stores layout:**

1. Provisions for easy receipts, storage and disbursement of materials and nearness to point of use.
2. Minimum handling and transportation of materials, good accessibility for handling equipments and personnel.
3. Adequate capacity provision for flexibility for future expansion.
4. Clear identification of materials, quick location of items and easy of physical counting.
5. Protecting against waste, deterioration and damage.
6. Design the buildings, physical appearance to create goodwill and to invite business activities.
7. Use compatible storage or display equipment to create good interior appearances for easy identification.
8. Plan storage for easy shelf-life rotation to permit FIFO control.
9. Provide enough safety for the materials according to their requirements.
10. Maintain a periodic house keeping and rearrangement plan.

Centralized versus Decentralized storing

The location of stores depends mainly to minimize handling of materials, volume of material and type of materials. Generally, the location of store is near to the consuming department for reducing the movement of the material and avoiding back tracing. In small industries, all materials are stored in a central store for better control of material utilization. The store manager will take over all the responsibility of handling the material, issue and receipt of materials. While we consider the large industries, there are different stores are possible according to the type of material or no. of units available. Decen-

tralized storing system needs a enough recording system when compare to centralized storing system.

Advantages of Centralization of stores

Centralized store result into the following benefits:

- Better supervision and control
- It requires fewer personnel to manage and thus involves reduced related costs.
- Better layout of stores.
- Inventory checks facilitates
- Optimum (minimum) stores can be maintained
- Fewer obsolete items.
- Better security arrangements can be made.

Disadvantages of Centralized stores

- Longer waiting time should to needed for getting the necessary materials.
- No. of materials stored is more, so proper recording should be needed for understanding the stock of the material.
- Centralized staff needs enough knowledge regarding all the materials which are used in a particular industry.
- All the departments cannot able to locate nearby the centralized store, so the transportation cost and handling equipment cost of a material should be taken into account.

Advantages of Decentralization of stores

- Reduced material handling and associated cost
- Convenient for every department to draw materials etc
- Less risk by fire or theft.
- Less chances of production stoppages owing to easy and prompt availability of materials.
- Maintenance and audit of materials is easy.
- Required materials can be identifiable.

Disadvantages of Decentralized stores

- Duplications of orders for materials from the supplier and also small order quantities from each user departments.

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- **More manpower is required.**
- **More storage space is required.**
- **Standardization of material is not possible.**
- **Higher chances of risk and theft of materials.**

7.4 MEASUREMENT OF STORES EFFICIENCY

The performance of stores is evaluated by repository of inventory worth crores of rupees and how well the material is maintaining for the future use. The performance can be done through qualitative aspects also. The quantitative techniques used for the evaluation are:

$$\text{Stores Efficiency Index} = \frac{\text{No. of requisition delivered on time}}{\text{Total no. of requisitions}}$$

$$\text{Space utilization Index} = \frac{\text{Area used for storage}}{\text{Total storage area available}}$$

$$\text{Obsolescence Index} = \frac{\text{Value of non-moving items}}{\text{Total inventory value}}$$

$$\text{Storage loss Index} = \frac{\text{Value of inventory cost due to damage, obsolescence and Pilferage}}{\text{Average value of inventory.}}$$

Subjective measurement is done through such factors as stock out situation, reducing non-moving items, checking of records maintained hose keeping and handling.

> ***Check Your Progress***
> 1. Define storage system.
> 2. Write some of the advantages and disadvantages of centralized and decentralized storing.
> 3. How do you measure the stores efficiency?

7.5 SUMMARY

Store occupies an important place in the operations of business or industrial establishment. Store keeping is primarily a service function in which the store keeper acts as a custodian of all items carried in the store. Store keeping may be defined as a function of receiving, storing and issue of raw materials, bought out parts and components, spare parts, tools, consumables, stationary items to the user departments which have indented for the same.

Materials should be protected from ill-effects of humidity, sunlight, dust as well as biological and chemical agents. Metals should be painted with oil or grease or covered with mineral jelly. Cast iron surface should be protected by bituminous paint. Wood should be painted with creosote oil to protect it from insects. Textiles are prone to be attacked by wooly bear and moth; these are protected with naphthalene balls. Rubber goods tend to harden with time and crack.

The location of stores depends mainly to minimize handling of materials, volume of material and type of materials. Generally, the location of store is near to the consuming department for reducing the movement of the material and avoiding back tracing. The performance of stores is evaluated by repository of inventory worth crores of rupees and how well the material is maintaining for the future use. The performance can be done through qualitative aspects also.

7.6 ANSWERS TO "CHECK YOUR PROGRESS"

1. Store keeping is primarily a service function in which the store keeper acts as a custodian of all items carried in the store. Store keeping may be defined as a function of receiving, storing and issue of raw materials, bought out parts and components, spare parts, tools, consumables, stationary items to the user departments which have indented for the same. It is the aspects of material control concerned with the physical storage of materials and goods.

   Stores are mainly classified as i) Raw materials stores, ii) Component stores iii) consumable materials stores iv) Spare parts stores v) Maintenance materials stores vi) Scrap or disposal stores (Scrap yard)

2. Some of the objectives of storage management are:

   To facilitate a balance and smooth flow of raw materials, components, tools and any other items necessary to meet production requirements.

   To maintain optimum stock of materials to compensate for irregular supplies by suppliers

   To provide codification of stored items for easy recognition

   To facilitate quantity purchases at discount prices.

   To maintain record of all incoming materials and issue of materials to user departments

3. In industrial engineering, the internal arrangement of a store is known as Layout. It is also called as "Work system design". Stores layout is a fundamental factor in determining the efficient performance of

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the stores department. An optimum utilization of stores should neither back the furniture too closely nor too. A well planned layout of a store makes the storage work easy. The receipt and issue of store material becomes easy and convenient. It gives better appearance to the stores and reduces the chances of damages, wastage and accidents.

4. Some of the advantages and disadvantages of centralized and decentralized storing are:

Advantages of Centralization of stores

Centralized store result into the following benefits:

- Better supervision and control
- It requires fewer personnel to manage and thus involves reduced related costs.
- Better layout of stores.
- Inventory checks facilitates
- Optimum (minimum) stores can be maintained
- Fewer obsolete items.
- Better security arrangements can be made.

Disadvantages of Centralized stores

- Longer waiting time should to needed for getting the necessary materials.
- No. of materials stored is more, so proper recording should be needed for understanding the stock of the material.
- Centralized staff needs enough knowledge regarding all the materials which are used in a particular industry.
- All the departments cannot able to locate nearby the centralized store, so the transportation cost and handling equipment cost of a material should be taken into account.

Advantages of Decentralization of stores

- Reduced material handling and associated cost
- Convenient for every department to draw materials etc
- Less risk by fire or theft.
- Less chances of production stoppages owing to easy and prompt availability of materials.
- Maintenance and audit of materials is easy.
- Required materials can be identifiable.

Disadvantages of Decentralized stores

- Duplications of orders for materials from the supplier and also small order quantities from each user departments.
- More manpower is required.
- More storage space is required.
- Standardization of material is not possible.
- Higher chances of risk and theft of materials.

5. The performance of stores is evaluated by repository of inventory worth crores of rupees and how well the material is maintaining for the future use. The performance can be done through qualitative aspects also. The quantitative techniques used for the evaluation are:

$$\text{Stores Efficiency Index} = \frac{\text{No. of requisition delivered on time}}{\text{Total no. of requisitions}}$$

$$\text{Space utilization Index} = \frac{\text{Area used for storage}}{\text{Total storage area available}}$$

$$\text{Obsolescence Index} = \frac{\text{Value of non-moving items}}{\text{Total inventory value}}$$

$$\text{Storage loss Index} = \frac{\text{Value of inventory cost due to damage, obsolescence and Pilferage}}{\text{Average value of inventory.}}$$

Subjective measurement is done through such factors as stock out situation, reducing non-moving items, checking of records maintained hose keeping and handling.

7.7 FURTHER READING

- T. Minahan, (1998) "Is This The Future of Purchasing" Purchasing, Vol. 12, pp.42.
- "Sourcing Snags", Business Today, 22 December 1994 - 6 January 1995, pp. 152-161.

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STOCK VERIFICATION

8.1 Introduction to Stock Verification
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8.1 STOCK VERIFICATION

Every company is following some system to record the material flow in their organization with the help of store manager. The responsibility of store manager is to get the requisition of material from the user department, process the requisition by checking the material with code and other specification. Generally, store record shows the required material and their quantity of purchase which is recorded by the personnel of a store department. The system is operated by people and there is chance of committing mistakes by people in recording the quantity or specification of a material. For this reason, every inventory item should be physically cross checked against store record with actual consumption of material.

Most companies create an "inventory discrepancy" or "inventory short and over" account to absorb such discrepancies. Stock taking, also called stock verification is the process of ascertaining by counting or measuring whether the physical stock of materials tallies with the balance shown in the stock

records. Actual stock shown in the record doesn't or adjusted with the physical stock should be verify periodically for knowing the cost spend on the warehouse purpose.

8.1.1 Methods of physical stock verification

There are three methods to conduct stock verification

- Annual stock verification or Periodic verification
- Continuous stock verification or Perpetual verification
- Low point or Reorder point stock verification

Annual stock verification : Annual stock taking is the process of making a complete checking of quantity once a year of all raw materials, semi finished goods, finished goods, tools, purchase order, requisition and suppliers quotations. This stock verification is usually done at the end or closing stage of an each and every financial year. This can be done by stopping all production and operational activity for an entire day to verify the stock of material (finished, in progress, balance). This method cannot suitable for the seasonal business.

Continuous stock verification : continuous stock verification is also called as perpetual stock taking, is the process of taking physical count of a few items daily and weekly basis so that each material for consumption and stock should be verified at least once in a year. A more common approach is to relate the frequency of count to the usage value of classification such as ABC analysis, VED analysis, FSN analysis etc., under which items of high usage value are identified and verified for the usage level in a future.

The complete programme is plan in advance and synchronized according to the time and value of a material. The personnel involved in these verification methods should work as a team with other internal department persons. This method can be applicable for all types of industries and make a point of material flow in each and every month.

Reorder point stock verification : This is a process of physical verification of an item when its quantity falls below the reorder level. The store manager when working with this system has the responsibility of notifying actual to the department concern. The Reorder point approach minimize the time required for actual inventory work because of the small quantities of material. However, it has the disadvantage of producing an irregular inventory schedule because of time and quantity of material as a constraint for the day to day production operations.

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8.1.2 Stock Accounting

Stock accounting implies recording of all transactions which affect the stock status of different items. The stock status is constantly updated and recorded data reflects the latest position. The output required is the materials abstract. The opening balance of each item is listed and all transactions pertaining to that period are logged and the final balance is indicated. The stock ledger is printed by the line printer and available as a record.

8.2 STOCK VALUATION

Stock valuation enables an organization to know the financial strengths and weakness. Valuation of the inventories converts the physical quantities into monetary figures and becomes very crucial in judging the organization's performance. The stores personnel are normally not burdened with the valuation of stock or pricing the issues, as they are responsible only for the physical numerical count. Valuation of stocks has to be done on two occasions: a) while issuing to the consumers to enable the cost of production and b) when preparing the periodic performance statements to value the stocks on hand. Valuation of materials stocked in stores as inventory and material issued for production is necessary because of two reasons. There are

> **Check Your Progress**
>
> 1. Write a short note on stock verification.
> 2. What are the methods of physical stock verification?

1) Inventory valuation : Inventory valuation of converting physical quantities of material into monetary value (rupees)is necessary to judge the performance of materials management functions in terms of inventory turnover ratio and to control inventory to satisfy the norms set for inventory by top management.

Material costing : material costing, in terms of the valuation of the cost of material consumed by the user departments in order to estimate the cost of the products produced which forms the basis for pricing decisions.

Stock Valuation Methods

Stocks have two types of valuations. One is a value created using some type of cash flow, sales or fundamental earnings analysis. The other value is dictated by how much an investor is willing to pay for a particular share of stock and by how much other investors are willing to sell a stock for (in other words, by supply and demand). Both of these values change over time as investors change the way they analyze stocks and as they become more or less confident in the future of stocks.

The fundamental valuation is the valuation that people use to justify stock prices. The most common example of this type of valuation methodology is P/

E ratio, which stands for Price to Earnings Ratio. This form of valuation is based on historic ratios and statistics and aims to assign value to a stock based on measurable attributes. This form of valuation is typically what drives long-term stock prices.

The other way stocks are valued is based on supply and demand. The more people that want to buy the stock, the higher its price will be. And conversely, the more people that want to sell the stock, the lower the price will be. This form of valuation is very hard to understand or predict, and it often drives the short-term stock market trends.

There are many different ways to value stocks. The key is to take each approach into account while formulating an overall opinion of the stock. If the valuation of a company is lower or higher than other similar stocks, then the next step would be to determine the reasons.

Earnings Per Share (EPS). EPS is the total net income of the company divided by the number of shares outstanding. They usually have a GAAP EPS number (which means that it is computed using all of mutually agreed upon accounting rules) and a Pro Forma EPS figure (which means that they have adjusted the income to exclude any one time items as well as some non-cash items like amortization of goodwill or stock option expenses). The most important thing to look for in the EPS figure is the overall quality of earnings. Make sure the company is not trying to manipulate their EPS numbers to make it look like they are more profitable. Also, look at the growth in EPS over the past several quarters / years to understand how volatile their EPS is, and to see if they are an underachiever or an overachiever. In other words, have they consistently beaten expectations or are they constantly restating and lowering their forecasts?

The EPS number that most analysts use is the pro forma EPS. To compute this number, use the net income that excludes any one-time gains or losses and excludes any non-cash expenses like stock options or amortization of goodwill. Then divide this number by the number of fully diluted shares outstanding. You can easily find historical EPS figures and to see forecasts for the next 1–2 years by visiting free financial sites such as Yahoo Finance (enter the ticker and then click on "estimates").

By doing your fundamental investment research you'll be able to arrive at your own EPS forecasts, which you can then apply to the other valuation techniques below.

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Price to Earnings (P/E). Now that you have several EPS figures (historical and forecasts), you'll be able to look at the most common valuation technique used by analysts, the price to earnings ratio, or P/E. To compute this figure, take the stock price and divide it by the annual EPS figure. For example, if the stock is trading at $10 and the EPS is $0.50, the P/E is 20 times. To get a good feeling of what P/E multiple a stock trades at, be sure to look at the historical and forward ratios.

Historical P/Es are computed by taking the current price divided by the sum of the EPS for the last four quarters, or for the previous year. You should also look at the historical trends of the P/E by viewing a chart of its historical P/E over the last several years (you can find on most finance sites like Yahoo Finance). Specifically you want to find out what range the P/E has traded in so that you can determine if the current P/E is high or low versus its historical average.

Forward P/Es reflect the future growth of the company into the figure. Forward P/Es are computed by taking the current stock price divided by the sum of the EPS estimates for the next four quarters, or for the EPS estimate for next calendar of fiscal year or two.

P/Es change constantly. If there is a large price change in a stock you are watching, or if the earnings (EPS) estimates change, the ratio is recomputed.

Growth Rate. Valuations rely very heavily on the expected growth rate of a company. One must look at the historical growth rate of both sales and income to get a feeling for the type of future growth expected. However, companies are constantly changing, as well as the economy, so solely using historical growth rates to predict the future is not an acceptable form of valuation. Instead, they are used as guidelines for what future growth could look like if similar circumstances are encountered by the company. Calculating the future growth rate requires personal investment research. This may take form in listening to the company's quarterly conference call or reading press release or other company article that discusses the company's growth guidance. However, although companies are in the best position to forecast their own growth, they are far from accurate, and unforeseen events could cause rapid changes in the economy and in the company's industry.

And for any valuation technique, it's important to look at a range of forecast values. For example, if the company being valued has been growing

earnings between 5 and 10% each year for the last 5 years, but believes that it will grow 15 - 20% this year, a more conservative growth rate of 10 - 15% would be appropriate in valuations. Another example would be for a company that has been going through restructuring. They may have been growing earnings at 10 - 15% over the past several quarters / years because of cost cutting, but their sales growth could be only 0 - 5%. This would signal that their earnings growth will probably slow when the cost cutting has fully taken effect. Therefore, forecasting an earnings growth closer to the 0 - 5% rate would be more appropriate rather than the 15 - 20%. Nonetheless, the growth rate method of valuations relies heavily on gut feel to make a forecast. This is why analysts often make inaccurate forecasts, and also why familiarity with a company is essential before making a forecast.

Price Earnings to Growth (PEG) Ratio. This valuation technique has really become popular over the past decade or so. It is better than just looking at a P/E because it takes three factors into account; the price, earnings, and earnings growth rates. To compute the PEG ratio, divide the Forward P/E by the expected earnings growth rate (you can also use historical P/E and historical growth rate to see where it's traded in the past). This will yield a ratio that is usually expressed as a percentage. The theory goes that as the percentage rises over 100% the stock becomes more and more overvalued, and as the PEG ratio falls below 100% the stock becomes more and more undervalued. The theory is based on a belief that P/E ratios should approximate the long-term growth rate of a company's earnings. Whether or not this is true will never be proven and the theory is therefore just a rule of thumb to use in the overall valuation process.

Here's an example of how to use the PEG ratio. Say you are comparing two stocks that you are thinking about buying. Stock A is trading at a forward P/E of 15 and expected to grow at 20%. Stock B is trading at a forward P/E of 30 and expected to grow at 25%. The PEG ratio for Stock A is 75% (15/20) and for Stock B is 120% (30/25). According to the PEG ratio, Stock A is a better purchase because it has a lower PEG ratio, or in other words, you can purchase its future earnings growth for a lower relative price than that of Stock B.

Nerbrand Z. Given that investments are subject to revisions of future expectations the Nerbrand Z utilises uncertainty of consensus estimates to assess how much earnings forecasts can be revised in standard deviation terms before P/E rations return to normalised levels. This calculation is best done

with I/B/E/S consensus estimates. The market tend to focus on the 12 month forward P/E level but this ratio is dependent on earnings estimates which are never homogenous. Hence there is a standard deviation of 12 month forward earnings estimates.

The Nerbrand z is therefore expressed as

$$Z = \frac{\frac{P}{H[P/E]} - E12}{stdev(E12)}$$

where H[P/E] = normalised P/E, e.g. a 5 year historical average of 12 month forward P/E ratios.

E12 = mean 12 month forward earnings estimates

stdev(E12) = standard deviation of 12 month forward earnings estimates.

A negative number indicates that earnings can be downgraded before valuations normalise. As such, a negative number indicate a valuation adjusted earnings buffer. For example, if the 12 month forward mean EPS forecast is $10, the price of the equity is $100, the historical average P/E ratio is 15, the standard deviation of EPS forecast is 2 then the Nerbrand Z is -1.67. That is, 12 month forward consensus earnings estimates could be downgraded by 1.67 standard deviation before P/E ratio would go back to 15.

Return on Invested Capital (ROIC). This valuation technique measures how much money the company makes each year per dollar of invested capital. Invested Capital is the amount of money invested in the company by both stockholders and debtors. The ratio is expressed as a percent and you should look for a percent that approximates the level of growth that you expect. In its simplest definition, this ratio measures the investment return that management is able to get for its capital. The higher the number, the better the return.

To compute the ratio, take the pro forma net income (same one used in the EPS figure mentioned above) and divide it by the invested capital. Invested capital can be estimated by adding together the stockholders equity, the total long and short term debt and accounts payable, and then subtracting accounts receivable and cash (all of these numbers can be found on the company's latest quarterly balance sheet). This ratio is much more useful when you compare it to other companies that you are valuing.

Return on Assets (ROA). Similar to ROIC, ROA, expressed as a percent, measures the company's ability to make money from its assets. To measure the ROA, take the pro forma net income divided by the total assets.

However, because of very common irregularities in balance sheets (due to things like Goodwill, write-offs, discontinuations, etc.) this ratio is not always a good indicator of the company's potential. If the ratio is higher or lower than you expected, be sure to look closely at the assets to see what could be over or understating the figure.

Price to Sales (P/S). This figure is useful because it compares the current stock price to the annual sales. In other words, it tells you how much the stock costs per dollar of sales earned. To compute it, take the current stock price divided by the annual sales per share. The annual sales per share should be calculated by taking the net sales for the last four quarters divided by the fully diluted shares outstanding (both of these figures can be found by looking at the press releases or quarterly reports). The price to sales ratio is useful, but it does not take into account any debt the company has. For example, if a company is heavily financed by debt instead of equity, then the sales per share will seem high (the P/S will be lower). All things equal, a lower P/S ratio is better. However, this ratio is best looked at when comparing more than one company.

Market Cap. Market Cap, which is short for Market Capitalization, is the value of all of the company's stock. To measure it, multiply the current stock price by the fully diluted shares outstanding. Remember, the market cap is only the value of the stock. To get a more complete picture, you'll want to look at the Enterprise Value.

Enterprise Value (EV). Enterprise Value is equal to the total value of the company, as it is trading for on the stock market. To compute it, add the market cap (see above) and the total net debt of the company. The total net debt is equal to total long and short term debt plus accounts payable, minus accounts receivable, minus cash. The Enterprise Value is the best approximation of what a company is worth at any point in time because it takes into account the actual stock price instead of balance sheet prices. When analysts say that a company is a "billion dollar" company, they are often referring to its total enterprise value. Enterprise Value fluctuates rapidly based on stock price changes.

EV to Sales. This ratio measures the total company value as compared to its annual sales. A high ratio means that the company's value is much more than its sales. To compute it, divide the EV by the net sales for the last four quarters. This ratio is especially useful when valuing companies that do not

have earnings, or that are going through unusually rough times. For example, if a company is facing restructuring and it is currently losing money, then the P/E ratio would be irrelevant. However, by applying a EV to Sales ratio, you could compute what that company could trade for when its restructuring is over and its earnings are back to normal.

EBITDA. EBITDA stands for earnings before interest, taxes, depreciation and amortization. It is one of the best measures of a company's cash flow and is used for valuing both public and private companies. To compute EBITDA, use a companies income statement, take the net income and then add back interest, taxes, depreciation, amortization and any other non-cash or one-time charges. This leaves you with a number that approximates how much cash the company is producing. EBITDA is a very popular figure because it can easily be compared across companies, even if all of the companies are not profitable.

EV to EBITDA. This is perhaps one of the best measurements of whether or not a company is cheap or expensive. To compute, divide the EV by EBITDA (see above for calculations). The higher the number, the more expensive the company is. However, remember that more expensive companies are often valued higher because they are growing faster or because they are a higher quality company. With that said, the best way to use EV/EBITDA is to compare it to that of other similar companies.

Approximate valuation approaches

Average growth approximation:

Assuming that two stocks have the same earnings growth, the one with a lower P/E is a better value. The P/E method is perhaps the most commonly used valuation method in the stock brokerage industry. By using comparison firms, a target price/earnings (or P/E) ratio is selected for the company, and then the future earnings of the company are estimated. The valuation's fair price is simply estimated earnings times target P/E. This model is essentially the same model as Gordon's model, if k-g is estimated as the dividend payout ratio (D/E) divided by the target P/E ratio.

Constant growth approximation:

The Gordon model or Gordon's growth model is the best known of a class of discounted dividend models. It assumes that dividends will increase at a constant growth rate (less than the discount rate) forever. The valuation is given by the formula:

$$P = D \cdot \sum_{i=1}^{\infty} \left(\frac{1+g}{1+k}\right)^{i} = D \cdot \frac{1+g}{k-g}$$

and the following table defines each symbol:

Symbol	Meaning	Units
P	*estimated stock price*	\$ or € or £
D	*last dividend paid*	\$ or € or £
k	*discount rate*	%
g	*the growth rate of the dividends*	%

Limited high-growth period approximation:

When a stock has a significantly higher growth rate than its peers, it is sometimes assumed that the earnings growth rate will be sustained for a short time (say, 5 years), and then the growth rate will revert to the mean. This is probably the most rigorous approximation that is practical.

While these DCF models are commonly used, the uncertainty in these values is hardly ever discussed. Note that the models diverge for $k = g$ and hence are extremely sensitive to the difference of dividend growth to discount factor. One might argue that an analyst can justify any value (and that would usually be one close to the current price supporting his call) by fine-tuning the growth/discount assumptions.

Implied Growth Models

One can use the Gordon model or the limited high-growth period approximation model to impute an implied growth estimate. To do this, one takes the average P/E and average growth for a comparison index, uses the current (or forward) P/E of the stock in question, and calculates what growth rate would be needed for the two valuation equations to be equal. This gives you an estimate of the "break-even" growth rate for the stock's current P/E ratio. (Note : we are using earnings not dividends here because dividend policies vary and may be influenced by many factors including tax treatment).

Imputed growth acceleration ratio

Subsequently, one can divide this imputed growth estimate by recent historical growth rates. If the resulting ratio is greater than one, it implies that

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the stock would need to experience accelerated growth relative to its prior recent historical growth to justify its current P/E (higher values suggest potential overvaluation). If the resulting ratio is less than one, it implies that either the market expects growth to slow for this stock or that the stock could sustain its current P/E with lower than historical growth (lower values suggest potential undervaluation). Comparison of the IGAR across stocks in the same industry may give estimates of relative value. IGAR averages across an industry may give estimates of relative expected changes in industry growth (eg. the market's imputed expectation that an industry is about to "take-off" or stagnate). Naturally, any differences in IGAR between stocks in the same industry may be due to differences in fundamentals, and would require further specific analysis.

8.2.1 Valuation Strategies

The strategies of valuation of materials range from the conservative practices. The process of valuation of the material in the industry varies from place to place by considering the market price or cost of procurement whichever is less. The method of pricing or valuations of materials are:

- First In First out method (FIFO)
- Last In First out method (LIFO)
- Average price method or weighted average method
- Actual price method
- Replacement price or Market value method
- Standard price method
- Inflated price method.

First In, First Out (FIFO) Method

This is the oldest method of issuing the material which is received first ie., first come first out. The method ensure that the materials are issued at the actual cost what the cost spent for the purchase of the same material and stocks are valued as per the latest price paid in the market. The value of the material is increase or decrease once it not consumed at the correct time.

Last In, First Out (LIFO) Method

This method ensures that the material coming last are issued first. The advantage of this method is that production is charged at the latest price, reflecting the market condition, if materials are received recently. Hence, pricing charging decisions can be taken realistically under the LIFO system. Dur-

ing this period the actual price is same as that of latest price while issuing, thereby leading to lower reported profits and savings in taxes, when the price levels are fluctuating, LIFO tends to minimize unrealized gains or losses in inventory.

Average Price or Weighted Average Method

This method shows that issues are valued on the basis of a simple average price. The prices of purchases prior to any issues are added and the average price is calculated by dividing the total value by the number of purchase prices used. Weighted average is a realistic method, as it reflects the price levels resulting in stabilization of cost. The rate is calculated by dividing the total cost by the number of items and its rate is applied to issue of material. As more purchases are made, a new average rate is calculated and this new rate is applied to the subsequent issues.

Actual Price Method

In this method, actual cost is charged for the materials to be issued from the store. This method is used where the purchases are made for the specific purposes such as spare parts, tools and equipments. Each material receipt is recorded in a separate store ledger and the material issues are cost at actual purchase cost. This method is used where few costly items or non-standard materials are purchased to meet the requirements of production department and specific customer orders.

Replacement Price or Current Price Method

In this method, the materials issues are priced at the rate of market price on that date. The principle is that materials issued for any job of production on the particular date should be charged at the rate at which these materials could be replaced immediately from the new purchases on the same date. The method is used for materials of standard grades which are traded at commodity exchange. It is east to ascertain the current market price.

Standard Price or Standard Cost method

Standard Price method is a forecasted price method, where the prices of materials are fixed for the specific period of time such as three or six months by considering the value of material on the date of issue. The forecast price is calculated by means of market condition, usage rate, storage condition and trends of that material, so that a minimum average standard price is changed on the issuing date. The material receipts are recorded at the actual price sold with the predetermined standard price. The efficient use of material is truly

reflected because of the usage condition and demand in the market. The limitation of this method is that tock is under estimated in the context of rising prices and overestimated at the period of falling price.

Inflated Price Method

In this method, the cost of material charged is slightly inflated by a small percentage of the actual purchase price. This is because there may be certain types of material wastages incidental to material usage ie, loss, breakage, evaporation, waste pieces and the resulting loss should be uniformly spread on the remaining stock of a particular material.

8.3 DISPOSAL OF SURPLUS AND SCRAP

Surplus is the excess quantity of the material which is not consumed during the production. Surplus quantity should be disposed or make as a stock according to the nature of the material because some material can be used for the future and some may be perishable goods. Disposal of surplus generally create a free space in the warehouse, reduction of maintenance cost and new materials use at the time of requirement as that of technology. Scrap is a waste material that can be seen at the end or during the process of production. Scrap can be used as raw material for some other product or it occupies the space which cannot be used further. Scrap makes damage to the machinery or equipment and persons in the work place. Surplus and scrap materials should be taken care by the material department as their special function. There is basic reason to taken care the surplus and scrap materials which are listed below:

Disposal of Surplus:

Any surplus generated in the stores due to incorrect purchasing of quantity, partly damaged quantity, wrong forecast of demand for finished products. The purchasing department has to rectify this correction during the initial stage of the purchasing process. They have to clearly mention the specification or clear view of material which is actually meeting their requirements.

Alternative use of surplus:

Any surplus of an assembled product can be passed on to an alternative product made by the firm. The persons from the material department can solve the problem by discussing with designing and production departments.

Knowledge of Market:

Purchasing department knows market people who are the buyer and

seller of the scrap and surplus materials. The requirements of that material make the department to plan when to sale and buy the material according to the cost and quality of the materials. They doesn't have any rules and regulation of purchasing of that material with the actual cost or current value of a market.

Knowledge of slow moving items:

The material personnel are always classifying the materials according to the consumption or requirements in the production process or usage time in an organization. There are several inventory techniques which are used to control the surplus and make an effective design to utilize entire quantity of a material. VED, FSN analysis are the most useful inventory techniques.

8.3.1 Reasons for creation of surplus and scrap

Mismatching with supply and Demand

The forecasting of current market position with the particular product or raw material purchase for a material may be of excess quantity without predicting the actual need of production. The supply of raw material and reach of final product to market at the planned time and place also plays a vital role for creating a surplus, if it 's not process as per schedule. Economic order quantity (EOQ) a technique used in inventory method helps to indicate the material requirements at the right time, so that surplus of material can be reduced.

Design Change

If the market demand for certain design of product drops down or move to a decline stage suddenly, the raw material purchased for the product are consider as a surplus. Design of a particular product change according to the customer needs after introducing in the market or once technology development taking place in the production process also create a unexpected scrap of the material.

Customized product manufacture

During the manufacture of a large, costly machine for a special customer, several types of extra items are left over at the end of the project. This may be due to wrong estimate of quantity or incorrect quality or improper specification. These items also either falls in the category of surplus and scrap.

8.3.2 SCRAP

There are various categories of scrap, which are listed below:

Waste

Some raw materials, like sheet steel are available in standard width. The sheet metal parts made out of this standard width result in wastage. Similar problems arise during the purchase of bars of various standard sizes. Some wastage always occurs if paper machining allowances is not kept. Engineers make use of strip stock layout to minimize waste. Waste makes lots of incontinence in the sense of cleaning work, storage place, extra concentration for making the product (avoiding of adulteration).

Metal cutting waste

Factory shop floors are full of waste in turnings, boring, wood cuttings etc at the end of a shift. They are put back in the firm's foundry or sold as a scrap. Production defects result when a part is manufactured with errors, if it cannot rework or salvaged.

Damaged parts of machine

Damaged parts have to be disposed as a scrap. Containers, cartons, stickers, labels etc which bring as a raw material for damaged parts are also considered as a scrap in the case of limited production. Cutting tools which have been act as a outline for the product and burnt oils used in the machine parts are also consider as a scrap , if it not taken for rework or reuse purposes.

8.3.3 Disposal of Scrap

Disposal of scrap is done by public auction, annual contract or by tendering. The procedure of auction is given below:.

a) A list giving details should be circulated.

b) Sale should be on the basis of "as is where is"

c) Proper advertising should be done.

d) Supervision of auction will be done by personnel from stores and purchase as well as from accounts.

e) Highest bid should be verified.

f) The highest bid document will be signed by the officers concerned.

8.4 PERFORMANCE APPRAISAL OF MATERIAL DEPARTMENT

Performance appraisal is a critical analysis of the available data of a department to assess the effectiveness of the functions and working controls introduced as systems in the organization. It is known that suppliers, who are

evaluated by the materials management department, evaluate the material manager with regard to quality consciousness, adherence to payment schedule and his important decision making towards critical situation. While the managerial function of a material manager is also evaluate to know his skills and capabilities.

According to Gopalakrishnan, the evaluation of material management can either be done by external agencies or internally. Within the organization itself, the top management, usually at the end of the financial year and periodically during the year, evaluates the performance on the basis of inventory holding and obsolete items. The user departments evaluate the materials function in terms of the number and duration of the stock-out.

8.4.1 Performance Appraisal Evaluation and Ratios

The various ratios given by the different sections of material department is to improve the overall efficiency and effectiveness. There are given below:

Performance Appraisal receiving stores

$$\text{Demurrage index} = \frac{\text{Demurrage paid during the period}}{\text{Value of purchase made from outstation supplier during the period}}$$

$$\text{Percent delivery not on schedule} = \frac{\text{No. of GRRs where quantities are excess than schedule}}{\text{Total number of GRRs}}$$

$$\text{Percent defective deliveries} = \frac{\text{No. of GRRs with defects}}{\text{Total number of GRRs}}$$

$$\text{Defective material accounting index} = \frac{\text{No. of rejected GRRs, wherein materials returns partial}}{\text{Total number of GRRs}}$$

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$$\text{Clerical cost per GRR} = \frac{\text{Expenses (per period) of the receiving stores}}{\text{No. of GRRs (per period)}}$$

Evaluation of Stores Department

$$\text{Obsolescence index} = \frac{\text{No. of non-moving items}}{\text{Total number of items}}$$

$$\text{Storage loss index} = \frac{\text{Obsolescence and pilferage}}{\text{Average inventory investment}}$$

$$\text{Stock verification index} = \frac{\text{Value of discrepancies}}{\text{Average inventory investment}}$$

$$\text{Handling cost index} = \frac{\text{Total Handling cost}}{\text{Total value of material issued and received}}$$

$$\text{Scrap disposal index} = \frac{\text{Value of scrap disposed}}{\text{Total value of scrap}}$$

$$\text{Space utilization index} = \frac{\text{Area used for storage}}{\text{Total storage area available}}$$

Check Your Progress

3. Define inventory Valuation.
4. Write a short note on Return on Assets (ROA).
5. What are the methods of pricing or valuation of materials?
6. What is disposal of surplus and scrap?

8.5 SUMMARY

Every company is following some system to record the material flow in their organization with the help of store manager. The responsibility of store manager is to get the requisition of material from the user department, process the requisition by checking the material with code and other specification.

Most companies create an "inventory discrepancy" or "inventory short and over" account to absorb such discrepancies. Stock taking, also called stock verification is the process of ascertaining by counting or measuring whether the physical stock of materials tallies with the balance shown in the stock records. Stock accounting implies recording of all transactions which affect the stock status of different items.

The stock status is constantly updated and recorded data reflects the latest position. Stock valuation enables an organization to know the financial strengths and weakness. Valuation of the inventories converts the physical quantities into monetary figures and becomes very crucial in judging the organization's performance. The strategies of valuation of materials range from the conservative practices. The process of valuation of the material in the industry varies from place to place by considering the market price or cost of procurement whichever is less. Disposal of surplus generally create a free space in the warehouse, reduction of maintenance cost and new materials use at the time of requirement as that of technology. Scrap is a waste material that can be seen at the end or during the process of production. Scrap can be used as raw material for some other product or it occupies the space which cannot be used further.

8.6 ANSWERS TO "CHECK YOUR PROGRESS"

1. Every company is following some system to record the material flow in their organization with the help of store manager. The responsibility of store manager is to get the requisition of material from the user department, process the requisition by checking the material with code and other specification. Generally, store record shows the required material and their quantity of purchase which is recorded by the personnel of a store department. The system is operated by people and there is chance of committing mistakes by people in recording the quantity or specification of a material. For this reason, every inventory item should be physically cross checked against store record with actual consumption of material.
2. There are three methods of physical stock verification:-
   - Annual stock verification or Periodic verification
   - Continuous stock verification or Perpetual verification
   - Low point or Reorder point stock verification
3. Inventory valuation of converting physical quantities of material into monetary value (rupees)is necessary to judge the performance of mate-

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rials management functions in terms of inventory turnover ratio and to control inventory to satisfy the norms set for inventory by top management.

4. ROA, expressed as a percent, measures the company's ability to make money from its assets. To measure the ROA, take the pro forma net income divided by the total assets. However, because of very common irregularities in balance sheets (due to things like Goodwill, write-offs, discontinuations, etc.) this ratio is not always a good indicator of the company's potential

5. The method of pricing or valuations of materials are:

   First In First out method (FIFO)

   Last In First out method (LIFO)

   Average price method or weighted average method

   Actual price method

   Replacement price or Market value method

   Standard price method

   Inflated price method.

6. Any surplus generated in the stores due to incorrect purchasing of quantity, partly damaged quantity, wrong forecast of demand for finished products. The purchasing department has to rectify this correction during the initial stage of the purchasing process. They have to clearly mention the specification or clear view of material which is actually meeting their requirements.

   Disposal of scrap is done by public auction, annual contract or by tendering. The procedure of auction is given below:

   a) A list giving details should be circulated.
   b) Sale should be on the basis of "as is where is"
   c) Proper advertising should be done.
   d) Supervision of auction will be done by personnel from stores and purchase as well as from accounts.
   e) Highest bid should be verified.
   f) The highest bid document will be signed by the officers concerned.

8.7 FURTHER READING

· E. A. Silver, D. F. Pyke and R. Peterson, (1998) "Inventory Management and Production Planning and Scheduling", 3rd edition, New York: John Wiley.

· H. A. Taha, (2008) "Operations Research: An Introduction", 8th edition,New Delhi, Prentice hall Inc.

CHAPTER 9

VENDOR DEVELOPMENT AND MATERIAL REQUIREMENT PLANNING

9.1 Introduction Vendor Development

9.1.1 Sources of Suppliers Information

9.1.2 Vendor Evaluation and Vendor Rating

9.2 Material Requirement Planning

9.2.1 Objectives of MRP1

9.2.2 MRP System

9.2.3 MRP Logic

9.2.4 Management information from MRP

9.3 Summary

9.4 Answers to "Check Your Progress"

9.5 Further Reading

9.1 INTRODUCTION TO VENDOR DEVELOPMENT

Many companies are now confronted with diminishing growth opportunities, which results in a situation where an increase in turnover can only be realized at the expense of the competition and only with a great deal of effort. This leads to increased pressure on sales prices and consequently on cost prices and margins, which causes two developments.

- On the one hand it has resulted in shifts of power between purchasing and selling parties in many markets. Due to the fact that in many cases the market has changed from seller's market to buyer's market, the role of the buyer is now more dominant than a number of years ago.
- On the other hand the increasing pressure on sales prices and margins has resulted in an increased pressure on direct materials-related costs. Because the purchasing prices determine the sales prices in the industrial sector to a large extent, the company will be constantly on the look-out for opportunities to keep these prices as low as possible.

As a result of both developments, the purchasing and supply strategies of industrial companies have undergone major changes.

Several examples of these changes are presented below:-

1. Co-ordination of purchasing requirements: In companies with several manufacturing plants, important purchasing advantages can be realized by combining policy is seen to emerge in many European companies of this type, even across national borders. Traditionally this was already common for raw materials; at present however, a similar approach is used for the purchase of computer hardware and software, capital goods and components. Good examples of companies with an active policy concerning purchasing co-ordination are, apart from the automotive and computer industry, Shell, Philips electronics and Alcatel.

2. Integration of purchasing in logistics: Automation enables companies to improve materials planning and supply systems. It furthermore may significantly improve the productivity within the materials area. An integrated approach of materials management requires close cooperation between the production planning, inventory control, quality inspection and purchasing. To achieve succesful automation, system standardization is a prerequisite. Purchasing cannot be allowed to follow its own course. To ensure effective integration of the different materials related areas. Purchasing increasingly is integrated into supply chain management.

3. Integration of purchasing in engineering and production planning: In practice, supplier selection is determined to a large degree by the technical specifications. Once established, this specification is often very difficult to change. From a commercial point of view it is undesirable that specifications are defined towards a particular supplier; in that case purchasing often ends up with a monopolist, which seriously hampers negotiating. To prevent this it is desirable to include purchasing in the development process at an early stage. The goal is to make optimal use of purchasing knowledge of products and markets for the benefit of the product design.

4. Make or Buy: Practice shows that several production activities can be done cheaper and faster by specialized suppliers. Moreover, companies may take greater demands in terms of quality on external suppliers than on their own. This is why in some industrial branches, the purchasing to sales ratio has been steadily rising. For some companies these have resulted in detailed make or buy studies. Purchasing should always be closely involved in this type of study, because they are the logical source of market information.

5. Reciprocity agreements and compensation obligations: Companies operation on international markets is often obliges to compensate their sales turnover by counter purchase obligations. The recent opening up of the eastern European block has counter trade an actual issue. Buying from these countries may even open up interesting sales opportunities. Purchasing become involved in fulfilling such obligations
6. Total quality control and just-in-time production: In several companies a growing interest in quality improvement and increased productivity can be observed. The activities of the European foundation for Quality Management, initiated by the presidents of 14 European industries on 5 September 1988, illustrate the first; several EEC programmes, aimed at logistics, the second. There is a growing awareness in the international business scene that, if Europe wishes to remain competitive on a world scale in several sectors, Improvements must be made in both the level of costs and the level of quality of the end products.

E-Purchasing and E-Procurement

The Internet and e-commerce is drastically changing the way purchasing is done. Internet use in buying has led to the terms "e-purchasing" or "e-procurement." Certainly, communication needed in competitive bidding, purchase order placement, order tracking, and follow-up are enhanced by the speed and ease afforded by establishing online systems. In addition, negotiation may be enhanced and reverse auctions facilitated. Reverse auctions allow buying firms to specify a requirement and receive bids from suppliers, with the lowest bid winning.

E-procurement is considered one of the characteristics of a world-class purchasing organization. The use of e-procurement technologies in some firms has resulted in reduced prices for goods and services, shortened order-processing and fulfillment cycles, reduced administrative burdens and costs, improved control over off-contract spending, and better inventory control. It allows firms to expand into trading networks and virtual corporations.

Criteria for e-purchasing include:

- Supporting complete requirements of production (direct) and non-production (indirect) purchasing through a single, internet-based, self-service system.
- Delivering a flexible catalog strategy.
- Providing tools for extensive reporting and analysis.

- Supporting strategic sourcing.

The important responsibilities for the purchasing Executive are:-

1. To select the right source of supply.
2. To develop new suppliers.
3. To identify the suppliers who gives the product for minimum cost.

In other words, supplier selection and new source development are major contributions of the purchasing function and so should have properly planned approach. A good supplier actively participates and helps the purchase to meet his customer's requirements. Suppliers also contribute their specialized knowledge and help build quality into the purchasing company's products. For the selection, it is easy for purchaser to work out a preference pattern based on price, quality, and delivery, service land his geographical location, his technical ability and knowledge. The suppliers may be large, medium or small, who supplies raw materials, component, equipment, etc.

The factors which were considered to evaluate the functional aspects of vendor's selection are –

High Impact Factors:

- Delivery Reliability, and
- Quality / price ratio

Factors with middle values:

- General reputation
- Geographical location
- Technical ability and knowledge
- Technical inventiveness
- Supply of information and market surveys
- Extent of previous contact with the buyers

The vendor / suppliers may be large, medium or small companies and further they can broadly classified as suitable for –

1. Raw Material
2. Maintenance Repair and operating supplier
3. Components – Standard and Special
4. Capital equipment
5. Subcontracting
6. Services

9.1.1 Sources of Suppliers Information:

The sources of supply information are:

- Catalogue
- Trade Journals
- Trade Directories
- Newspaper Advertisements
- Telephone directory
- Government Publications
- Publications of Institutions and Manufacturers Association
- Industrial Advertising including Direct Mail
- Salesman's visits
- Trade Exhibits and Technical Exhibitions
- Industrial Product Finder

Sources of supply covering equipment, materials, price information and other details may be extracted from the above. All these, if indexed, properly filed and periodically updated, serve as a good reference not only to the purchasers but to others in the organization. The indexing should be based on product information and according to the names of suppliers and geographical purchasers should be fully aware the information of new product, new processes contained in these.

THE SUPPLIER:

Type of procurement involved greatly influences the factors to be considered in making the evaluation. The inventory procured to perform a "function" is the result of the basic types of effort:

- Structural or Engineering
- Manufacturing

Local purchase is a specific procurement involved for a locally available or "off the shelf" item, the buyer contacts a "commodity" vendor. When the requirement involves special design or performance features, such as tooling investment costs and start up time, the buyer assessing a vendor's capability should focus here on specific information on the suppliers financial health, quality, facilities, efficiency, industrial peace, technical excellence and position in industry.

a) Commodity suppliers:

It is undoubtedly the most significant factor and it is a vendor's willingness and ability to fill buyer requirements reliably. This is often the only advantage he can offer over his competitors.

PRICES are generally competitive for equivalent quality lines, but pricing structures may vary with respect to quantity discounts. This aspect offers opportunity for analysis and evaluation.

b) "Capability" Suppliers :

When the procurement is for unique requirements calling for special design, performance or reliability features and entailing special tooling, preparatory time and even capital investment, the buyer is virtually procuring vendor capability. This supplier becomes, in effect, an extension of the buyer's in-house resources, or, in other words, an external manufacturer. Qualifications should be in terms of technical, manufacturing, financial and management capabilities.

DEVELOPING A SOURCE OF SUPPLY:

The source development is important for import substitution, cost reduction and quality improvement. Source development needs are dependent on factors such as 'make or buy' decisions, amount of sub-contracting, break even points at manufacturing and plant capacity. In some cases a buyer has to create a satisfactory supplier. Also if existing suppliers cannot satisfy a company's needs, a logical alternative is to attempt to develop a new supplier.

Small Supplier Development :

It may be advantageous to encourage small firms in the engineering field so as to utilize the services of the new entrepreneurs. Small suppliers tend to need more assistance but purchasing personnel who have to watch for and develop new suppliers find that the small units are more responsive. Here, the purchase of raw materials and sometimes consumable tools by small ancillaries at comparable prices at which large consumers can obtain is a major problem.

Evaluation the sources of supplier:

The main factors involved in evaluating sources of supplier are Price, Quality, Delivery, Services, Location, Inventory policy of the supplier, Flexibility.

In addition to the main factors, several other factors are also consider for the assessment of suppliers by companies are Reserve capacity, Internal facility, Quality control procedures, Labour relation, Warranty, vendor sources.

9.1.2 Vendor Evaluation and Vendor Rating

It's not easy to identify good suppliers and records are maintained from some other sources about vendors which would help in their evaluation and rating. There are some typical questions the buyers should be posing when undertaking vendor capability surveys are:

- Will the vendor comply with the buyer's engineering standards and procedures for items made to buyer's design, and will produce drawings on buyer's format, when the requests it?
- What are the vendor's inspection procedures and controls?
- How frequently does he calibrate tools, gauges, and test equipment for meeting primary engineering standards?
- What are his procedures of in-process inspection and quality control?
- What is his procedure for receiving inspection?
- What is the nature of his planning, scheduling and inventory control system?
- Will he furnish price breakdowns by cost elements on fixed price contracts?
- Does he have any objection to contracting on other than a fixed price basis?
- Does he employee learning curves in projecting labour costs?
- Will he designate specific individuals in his engineering, production and financial organization from whom the buyer can obtain pertinent information and data as he requires it?
- How has he performed for other customers?

Techniques in Vendor Rating

The most common methods used in vendor rating are:

a) Categorical method:

A vendor's performance under the categorical method is based on the buyer's individual experience with the suppliers. Each vendor is assigned a grade preferred neutral or unsatisfactory after a careful analysis of his performance against a list of selected factors such as quality, delivery, price and services etc.,

It's usual to circulate the evaluation list to the department concerned with the vendor's item. Individual involved traditionally include personnel from purchasing, design, quality control, inspection, receiving and accounts depart-

ments. Each department evaluates each vendor against the performance factor consider important for the department. Inspection evaluates the vendor effects for trouble free suppliers: accounts for accuracy of invoices, timely dispatches of documents and issuance of credit notes etc., such an evaluation give some general ideas as to how well each vendor is satisfying their requirements of the individual departments. Each vendor is then assigned a democratic group evaluation.

b) Weighted point method

A vendor's performance under the weighted point method is assessed on the basis of certain selected factors such as quality, price, delivery and services. Each factor is assigned a weight which varies from company to company, depending upon the buyer's judgment about relative importance of the factor. This is a frequently used method is to determine each vendors performance against each factor. The performance is expressed in terms of individual ratings called quality rating, delivery rating, price rating and service rating.

Check Your Progress

1. Briefly explain Vendor Development.
2. What is E – purchasing and E – procurement?

c) The Cost ratio method

The cost ratio method is based on the calculation of the following ratios

$$CR = QR + DR + SR$$

Quality cost ratio expresses the ratio of quality costs and the cost of total purchases from the vendor, visits to the vendor's plant, cost of appraisal, and cost of rework. This ratio is termed quality rate.

A delivery cost includes cost of emergency transportation moving to delayed supply, email, fax, trunk call etc., as a fraction of cost of purchases.

Service Cost is evaluated on the basis of a point rating awarded to the supplier on the basis of his ability to provide good services.

9.2 MATERIAL REOUIREMENT PLANNING

Material Requirement Planning (MRP) is a contemporary concept in material planning for calculating the requirement of materials, which are used to plan and control the manufacturing operations. MRP is a technique used to prepare the schedule for material requirements, which is specified in the master production schedule of an organization. Basically this technique resolves what components are needed, how much quantity is needed, when it is needed and when they should be ordered so that the availability of concern material in time makes the smooth functioning of various operations in an organization.

"Material Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy the master production schedule requirements of an organization"

MRP concept is implied with the help of master production schedule, bill of materials, inventory status and demand forecast.

9.2.1 Objectives of MRP

1. To determines the inventory level of materials in each and every operation, so that the inventory cost can be reduced.
2. To identify the material quantities, timing when it's needed, availabilities and procurement of the required material for avoiding delays in production and delivery lead time.
3. To improve customer service by meeting delivery schedules promised and forecast the demand for required products.
4. To increase the efficiency of production system by coordinating various operations without any interruption in their flow of materials

9.2.2 MRP SYSTEM

MRP is a system of planning and scheduling the time based material requirement for production operations. It combines inventory control with production planning and update the material requirements from the planned quantities given in master production schedule. The feature of the system depends on continuous adjustment in material requirement with the changing production schedule. The important elements of the MRP system are:

1. A master production schedule
2. A inventory status file
3. Bill of material (BOM)

Master Production Schedule (MPS)

Master Production Schedule is the backbone of MRP system. MPS is a series of time phased quantities for each item that a company produces, indicating how many and when. MPS s initially developed from customer orders or from forecast of demand. The MRP system accepts whatever the master schedule demands and translates MPS end items in to specific component requirements. Most systems then make a simulated trial run to determine whether the proposed master schedule can be satisfied. The combination of the following three is called MPS.

Service &Support Optimization On Going Analysis

Inventory status file

Every inventory item being planned must have an inventory status file which gives complete and update information on the quantities, gross requirements, schedule receipts and planned order releases for the item. It also includes planning information such as lot sizes, lead time, safety stock levels and scrap allowances.

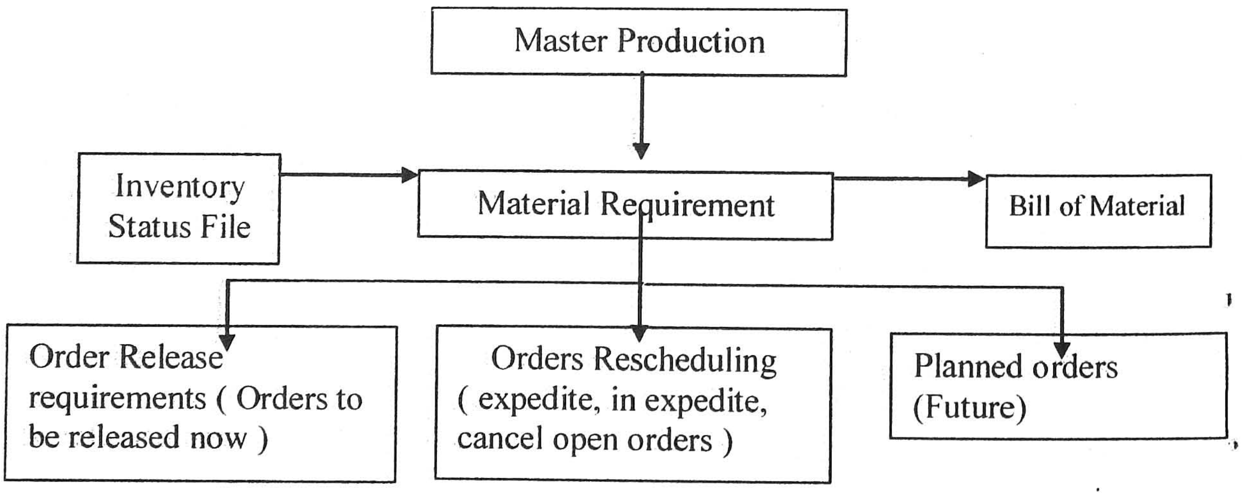
Generally, inventory status file is used to keep data about the planned and actual item of the material, consumption of material quantity for every operations and adequate stock to meet the requirements for a current period.

Bill of Materials (BOM)

The bill of materials approach is an important aspect in production planning. It identifies how each end product is manufactured, specifying all subcomponents items, their sequence of buildup, and their quantity in each finished unit.

When a design engineer completes the design of a part or an assembly, he makes a list of all components required to manufacture the item. The bill of material with a production schedule is sent directly to purchasing department as a notification for need of materials. The purchasing department sends a copy to a store for knowing the current inventory level of a particular material and after checking the updated inventory status file they go for authorization of that material.

Bill of material is explodes according to their requirements and specific code is given to each and every material used for the manufacturing of a particular product.



9.2.3 MRP Logic

MRP processing logic accepts the master schedule and determines the components schedules for successfully low level items of the product structures. It calculates for each item in each product structure and for each time period in the planning horizon how many of that items are required (Gross requirements) how many units from inventory are already available, the net quantity that must be planned (planned order receipts).

The terminologies which are involved in doing the MRP calculation are as follows:

- Projected requirements
- Planned order release
- Economic order quantity
- Scheduled receipts
- Stock on hand

Stock on hand is the level of inventory at the end of each period. Generally, the initial on hand quantity if exists for the final product / semi finished product is given in the input. For each period the stock on hand is computed by using the formula:

$$SOH_t = SOH_{t-1} + R_t - PR_t$$

Where,

SOH_t - stock on hand at the end of period t.

SOH_{t-1} - stock on hand at the end of period t-1.

PR_t - projected requirements of the period t.

R_t - scheduled receipt of the period t.

Net requirements are calculated by adjusting for existing inventory, items already on order as recorded in inventory status file.

Net Requirements = Projected Gross Requirements – [Inventory on hand + scheduled Receipts]

9.2.4 Management information from MRP

MRP is done with the help of computer programs using material requirement packages. For this purpose, the input system requires the corporate business plans, aggregate production plans, sales forecast, master production schedules, inventory status file and parts explosion list or the bill of materials. The output includes plant order schedules, order release and change to plant orders. The secondary output comprises of planning reports, performance re-

ports, exemption reports and inventory transactions. The above outputs are used for management to measure the performance of vendors; cost involved in each activity and makes accuracy in their forecast technique.

9.3 SUMMARY

Companies are now confronted with diminishing growth opportunities, which results in a situation where an increase in turnover can only be realized at the expense of the competition and only with a great deal of effort. The Internet and e-commerce is drastically changing the way purchasing is done. Internet use in buying has led to the terms "e-purchasing" or "e-procurement." The source development is important for import substitution, cost reduction and quality improvement. Source development needs are dependent on factors such as 'make or buy' decisions, amount of sub-contracting, break even points at manufacturing and plant capacity. In some cases a buyer has to create a satisfactory supplier. Also if existing suppliers cannot satisfy a company's needs, a logical alternative is to attempt to develop a new supplier.

MRP is a technique used to prepare the schedule for material requirements, which is specified in the master production schedule of an organization. Master Production Schedule is the backbone of MRP system. MPS is a series of time phased quantities for each item that a company produces, indicating how many and when. MRP processing logic accepts the master schedule and determines the components schedules for successfully low level items of the product structures. MRP is done with the help of computer programs using material requirement packages. For this purpose, the input system requires the corporate business plans, aggregate production plans, sales forecast, master production schedules, inventory status file and parts explosion list or the bill of materials.

> ***Check Your Progress***
>
> 3. Write a short note on Material Requirement Planning.
> 4. What is master Production Schedule?

9.4 Answers to "Check Your Progress"

1. Many companies are now confronted with diminishing growth opportunities, which results in a situation where an increase in turnover can only be realized at the expense of the competition and only with a great deal of effort. This leads to increased pressure on sales prices and consequently on cost prices and margins, which causes two developments.

   - On the one hand it has resulted in shifts of power between purchasing and selling parties in many markets. Due to the fact that in many cases the market has changed from seller's market to buyer's

market, the role of the buyer is now more dominant than a number of years ago.

- On the other hand the increasing pressure on sales prices and margins has resulted in an increased pressure on direct materials-related costs. Because the purchasing prices determine the sales prices in the industrial sector to a large extent, the company will be constantly on the look-out for opportunities to keep these prices as low as possible.

As a result of both developments, the purchasing and supply strategies of industrial companies have undergone major changes.

2. The Internet and e-commerce is drastically changing the way purchasing is done. Internet use in buying has led to the terms "e-purchasing" or "e-procurement." Certainly, communication needed in competitive bidding, purchase order placement, order tracking, and follow-up are enhanced by the speed and ease afforded by establishing online systems. In addition, negotiation may be enhanced and reverse auctions facilitated. Reverse auctions allow buying firms to specify a requirement and receive bids from suppliers, with the lowest bid winning.

E-procurement is considered one of the characteristics of a world-class purchasing organization. The use of e-procurement technologies in some firms has resulted in reduced prices for goods and services, shortened order-processing and fulfillment cycles, reduced administrative burdens and costs, improved control over off-contract spending, and better inventory control. It allows firms to expand into trading networks and virtual corporations.

3. Material Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy the master production schedule requirements of an organization.

4. Master Production Schedule is the backbone of MRP system. MPS is a series of time phased quantities for each item that a company produces, indicating how many and when. MPS s initially developed from customer orders or from forecast of demand. The MRP system accepts whatever the master schedule demands and translates MPS end items in to specific component requirements. Most systems then make a simulated trial run to determine whether the proposed master schedule can be satisfied. The combination of the following three is called MPS.

9.5 FURTHER READING

- R. L. Frrancis and J. A. White, (1977) “facilities Layout and Location: An Analytical Approach”, Englewood Cliffs, NJ: Prentice-Hall.
- P. Y. Huang and C. S. Chen, (1986) “Flexible Manufacturing Systems: An Overview and Bibliography”, Production and Inventory Management, 3rd quarter, pp. 80-89.
- S. Nahmias, (2000) “Production and Operations Analysis” 4th edition, New York: McGraw-Hill Publishing Co.

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MODERN MANUFACTURING METHODS

10.1 Manufacturing Resource Planning (MRP II)

10.1.1 Gozinto Matrix

10.2 JUST – IN TIME (JIT) Concepts

10.2.1 Benefits and Problems

10.3 KANBAN

10.3.1 Japanese KANBAN Process

10.3.2 Advantage of the KANBAN Process

10.4 Summary

10.5 Answers to "Check Your Progress"

10.6 Further Reading

10.1 MANUFACTURING RESOURCE PLANNING (MRP II)

MRP II or manufacturing resource planning pioneered by Oliver White, is an improvement over the material requirement planning discussed so far. The system uses a set of computer supported planning and scheduling tools to control production, cash flow, labour, capacity utilization, material purchase and inventory level. MRP II system co ordinates manufacturing, purchasing, sales, finance, human resource as an integrated system for effective production function. This system monitors the production and helps for preplan production activity.

MRP II has been defined by APICS (American Production and Inventory Control Society) as:

A method for effective planning of all the resources of manufacturing company, ideally it addressed operational planning in units, financial planning in rupees and has a simulation capability to answer "what-if" question. It is made up of variety of functions each linked together for a capacity and priority. Output from various functions would be integrated with financial reports such as business plan, the purchase commitment report, shipping, budget, inventory, production."

MRP II is a logical extension that goes beyond the computations for material requirements. It aims at addressing the entire manufacturing function

rather than just a single task within that function. This is very significant improvement in terms of integration that has been achieved by the use of Information Technology.

The MRP II or Manufacturing Resource Planning has different functions, namely

a) Business planning

b) Production planning

c) Master production scheduling

d) Materials requirement planning

e) Capacity requirement planning

f) Ordering system

The process shown below involves developing a production plan from the business plan to specify monthly levels of production for each product line. The production department starts their committed quantity with the guidance of material availability, financial position and manpower. The production plan helps to prepare master production schedule and gives weekly quantities of production with a specify product line. Then the capacity available is roughly determined. Master schedule used to create a MRP of a required material for production. Now the estimated capacity needed for the production in each work area is analyzed according to the business plan. The execution of actual production with control limits ensures the entire operations as specified in master production schedule.

MRP II – An Integrated System for Planning & Control

Accurate Stock Status :

This is a critical requirement. As MRP accuracy depends upon the on hand stock accuracy, it is essential to ensure the stock figures are accurate. Generally organizations do a physical counting before going live and update their inventory records.

Accurate On-Order Status:

As MRP logic takes into consideration, the quantity on order this data is important. Let us look at a situation. A company X releases a PO on a vendor V for an Item A. Qty expected is 800 by due date. Now Vendor V dispatches a quantity of 200 as a first installment. In the mean time the requirements at X have changed and there is no need of A anymore. Immediately buyer at X makes a call to Vendor and informs him not to send the

remaining material anymore. At some stage later, there is a requirement of 1000 for Item A. MRP recommends for a quantity of 400 (1000-600) only as the remaining 600 is expected from the previous PO. However, 600 will NOT come as was instructed by the buyer. Here the issue is, communication to Vendor has been completed, but to the system it was not done. So it would result in a short fall of 600 pieces. Sometimes this could result in ordering excess material too.

Accurate Lead Times

MRP calculations are Time Phased. They work on the principle that, Material should be in stock, only when it is just required, not before, not later. So it is very important to get the lead times more accurately. There are surely practical difficulties for arriving at the lead times. Lead times are divided into two categories. Fixed lead times and variable lead times. Fixed lead times are those, which are independent of LOT sizes. Variable lot sizes depend upon the Lot size to be produced or procured.

Procurement lead times are more difficult to predict than the production lead times. The assumption here is that, controlling internal production is easier than the Vendor lead times. Though many may disagree to this statement, if the organization is big and internal delays for decision making is rampant.

Production lead times are generally accurate and are available in the routing descriptions. However, care should be taken to identify the lead times based on the BOM defined for that particular part.

Accurate Demand

Another very important factor before MRP is implemented is to get the Demand accuracy. The demand should be expressed in the production units. Independent demand could include, the open orders, backlog, anticipation and spare parts requirement. This is one of the most difficult part. In many organizations, this could flow down from Master Production Schedule Planning(MPSP). *MPSP is a statement of production, not a Sales and operating plan.* While MPSP is prepared at family level, MRP drills down to SKU level.

There are many books which present examples of MRP calculations. So I am assuming that the readers would refer to that material. I would be too happy to present a few examples here if there is a request.

If the recommendations are in correct due to any of the factors listed above, planners will lose faith on the MRP system and will go back to their

previous methods of planning based on some excel sheets or other such tools. This will negate the integration with other modules and the REAL benefits of MRP are neither achieved nor perceived.

SAFETY STOCKS IN MRP(MATERIAL REQUIREMENT PLANNING) SYSTEM

- *Fixed quantity buffer stocks*
- Good rule of thumb: Set buffer = max. demand likely in a single period
- Never generate order solely to replenish buffer stocks
- Safety time method
- Simply order early
- Distorts LTs and priorities
- Better than buffer stocks for items with infrequent demand
- Also better for purchases outside company
- *Increase in gross requirements*
- Should be done at end item level only so that
  - » Components available in matched sets
  - » Safety stocks are not duplicated at different levels

10.1.1 GOZINTO MATRIX

The "Gozinto" philosophy gives the matrix method of describing the relationship between the end product explosion and their subassemblies as well as with the individual components that make up the final product. This philosophy describes the 'goes-into' relationship of components into end products to obtain the bill of materials. This process involves developing immediate coherent relationship of individual components, intermediate assemblies and final product, in the form of a total matrix. The use of matrix methods facilitates computerization. If the "gozinto" matrix is fed into the computer, then with the help of lead time, the overall requirements and schedule of deliveries of components can be obtained from the computer.

10.2 JUSI – IN TIME (JIT) Concepts

OBJECTIVES

- Produce only the products the customer wants.
- Produce products only at the rate that the customer wants them.
- Produce with perfect quality

- Produce with minimum lead time.
- Produce products with only those features the customer wants.

Just-In-time or JIT, is a management philosophy aimed at eliminating manufacturing wastes by producing only the right amount and combination of parts at the right place at the right time. This is based on the fact that wastes result from any activity that adds cost without adding value to the product, such as transferring of inventories from one place to another or even the mere act of storing them.

The goal of JIT, therefore, is to minimize the presence of non-value-adding operations and non-moving inventories in the production line. This will result in shorter throughput times, better on-time delivery performance, higher equipment utilization, lesser space requirement, lower costs, and greater profits.

JIT finds its origin in Japan, where it has been in practice since the early 1970's. It was developed and perfected by Taiichi Ohno of Toyota, who is now referred to as the father of JIT. Taiichi Ohno developed this philosophy as a means of meeting customer demands with minimum delays. Thus, in the olden days, JIT is used not to reduce manufacturing wastage, but primarily to produce goods so that customer orders are met exactly when they need the products.

JIT is also known as lean production or stockless production, since the key behind a successful implementation of JIT is the reduction of inventory levels at the various stations of the production line to the absolute minimum. This necessitates good coordination between stations such that every station produces only the exact volume that the next station needs. On the other hand, a station pulls in only the exact volume that it needs from the preceding station.

The JIT system consists of defining the production flow and setting up the production floor such that the flow of materials as they get manufactured through the line is smooth and unimpeded, thereby reducing material waiting time. This requires that the capacities of the various work stations that the materials pass through are very evenly matched and balanced, such that bottle necks in the production line are eliminated. This set-up ensures that the materials will undergo manufacturing without queuing or stoppage.

Another important aspect of JIT is the use of a 'Pull' system to move inventories through the production line. Under such a system, the require-

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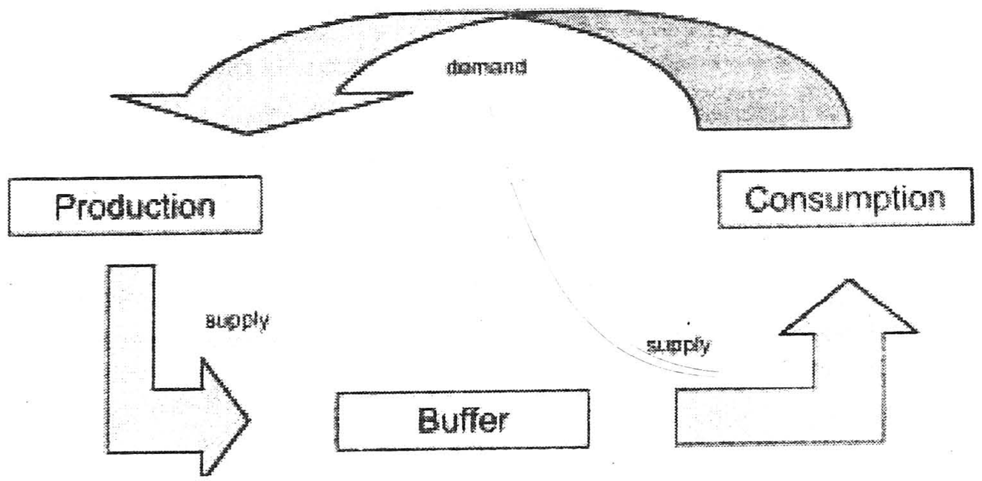
ments of the next station are what modulate the production of a particular station. It is therefore necessary under JIT to define a process by which the pulling of lots from one station to the next is facilitated.

JIT is most applicable to operations or production flows that do not change, i.e., those that are simply repeated over and over again. An example of this would be an automobile assembly line, wherein every car undergoes the same production process as the one before it.

JIT has likewise been practiced successfully by some semiconductor companies. Still, there are some semiconductor companies that don't practice JIT for the simple reason that their operations are too complex for JIT application. On the other hand, that's precisely the challenge of JIT – creation of a production set-up that is simple enough to allow JIT.



TYPES OF WASTE

- Transportation waste
- Process Waste
- Inventory Waste
- Waste of motion
- Waste from product defects
- Waiting time
- Overproduction

JIT TACTICS

- *Single Minute Exchange of Dies (SMED)*
- Statistical Process Control
- Use of standard containers
- Doable stable schedules with adequate visibility

- *TAKT-Time*
- 5-S Program
- Kaizen Event Visual control
- Flexible workers
- Tools at the point of need
- Product redesign
- Group Technology
- Total Productive Maintenance

10.2.1 BENEFITS AND PROBLEMS

Benefits that JIT concept can provide to the company are huge and very diverse. The main benefits of JIT are listed below:

1. *Reduced set up times in warehouse* - the company in this case can focus on other processes that might need improvement;

2. *Improved flows of goods in/through/out warehouse* - employees will be able to process goods faster;

3. *Employees who possess multi-skills are utilized more efficiently* – the company can use workers in situations when they are needed, when there is a shortage of workers and a high demand for a particular product;

4. *Better consistency of scheduling and consistency of employee work hours* - if there is no demand for a product at the time, workers don't have to be working. This can save the company money by not having to pay workers for a job not completed or could have them focus on other jobs around the warehouse that would not necessarily be done on a normal day;

5. *Increased emphasis on supplier relationships* - having a trusting supplier relationship is important for the company because it is possible to rely on goods being there when they are needed;

6. *Supplies continue around the clock keeping workers productive and businesses focused on turnover* - employees will work hard to meet the company goals.

Also, the benefits of JIT include: better quality products, higher productivity and lower production costs.

It is certainly that JIT concept can improve business performance and efficiency. Employee morale is likely increased and that is one most important benefit that comes from using the foregoing concept. Of course, we must not forget that now the company is allowed to remain competitive.

NOTES

Check Your Progress

1. What are the objectives of MRP II.
2. Write some of the functions of MRP II.
3. Explain JIT.

10.3 KANBAN

Japanese are good at manufacturing. Just ask any global producers of automobiles, copiers, or personal electronics what happened in the 1980s. They will probably tell you how the Japanese captured a large share of the global-market by creating world-class standards in design, materials, and management. What is often overlooked is the attempt to understand how the Japanese industry succeeds at the services that support the manufacturing process (Krajewski et al, 1987: 40). Within the production field, the Kanban process is the most significant of these services.

The concept of time-based management is nothing new for managers outside of Japan and has been in practice for many years. However, the Kanban process involves more than just in time deliveries and inventory control. Briggs (1993: 29) notes that Kanban process components are the most 'exportable' of Japanese techniques, but the complete process itself has not yet been successfully adopted outside Japan.

The Japanese refer to Kanban as a simple parts-movement system that depends on cards and boxes/containers to take parts from one work station to another on a production line. Kanban stands for Kan- card, Ban- signal. The essence of the Kanban concept is that a supplier or the warehouse should only deliver components to the production line as and when they are needed, so that there is no storage in the production area. Within this system, workstations located along production lines only produce/deliver desired components when they receive a card and an empty container, indicating that more parts will be needed in production. In case of line interruptions, each work-station will only produce enough components to fill the container and then stop (Roos, 1992: 112). In addition, Kanban limits the amount of inventory in the process by acting as an authorization to produce more inventory. Since Kanban is a chain process in which orders flow from one process to another, the production or delivery of components is pulled to the production line. In contrast to the traditional forecast oriented method where parts are pushed to the line (Roos, 1992: 113). The Kanban method described here appears to be very simple. However, this "visual record" procedure is only a sub-process in the Japanese Kanban management system.

PROPERTIES OF KANBAN

1. Visualize the workflow

The workflow of the knowledge work of today is inherently not visible

as it is "hidden" in information systems. Visualizing the flow of work and making it visible is core to building an understanding how work works. Without understanding the workflow making the right changes is harder. A common way to visualize the workflow is to use a card wall with cards and columns. The columns on the card wall representing the different states or steps in the workflow and the cards the feature/story/task/result of the workflow.

2. Limit WIP

Limiting work-in-progress implies that a pull system is implemented on parts or all of the workflow. The pull system will act as one of the main stimuli for continuous, incremental and evolutionary changes to your system. The pull system can be implemented as a kanban system, a CONWIP system, a DBR system, or some other variant. The critical elements are that work-in-progress at each state in the workflow is limited and that new work is "pulled" into the new information discovery activity when there is available capacity within the local WIP limit.

3. Manage Flow

The flow of work through each state in the workflow should be monitored, measured and reported. By actively managing the flow the continuous, incremental and evolutionary changes to the system can be evaluated to have positive or negative effects on the system.

4. Make Process Policies Explicit

Until the mechanism of a process is made explicit it is often hard or impossible to hold a discussion about improving it. Without an explicit understanding of how things work and how work is actually done, any discussion of problems tends to be emotional, anecdotal and subjective. With an explicit understanding it is possible to move to a more rational, empirical, objective discussion of issues. This is more likely to facilitate consensus around improvement suggestions.

5. Improve collaboratively (using models & the scientific method)

The Kanban Method encourages small continuous, incremental and evolutionary changes that stick. When teams have a shared understanding of theories about work, workflow, process, and risk, they are more likely to be able to build a shared comprehension of a problem and suggest improvement actions which can be agreed by consensus. The Kanban Method suggests that a scientific approach is used to implement continuous, incremental and evolutionary changes. The method does not prescribe a specific scientific method to use.

10.3.1 JANPANESE KANBAN PROCESS

Most Japanese manufacturing companies view the making of a product as continuous-from design, manufacture, and distribution to sales and customer service. For many Japanese companies the heart of this process is the Kanban, a Japanese term for "visual record", which directly or indirectly drives much of the manufacturing organization. It was originally developed at Toyota in the 1950s as a way of managing material flow on the assembly line (Perelman, 1994: 85). Over the past three decades the Kanban process, which Bernstein (1984: 48) identifies as "a highly efficient and effective factory production system", has developed into an optimum manufacturing environment leading to global competitiveness.

The Japanese Kanban process of production is sometimes incorrectly described as a simple just-in-time management technique, a concept which attempts to maintain minimum inventory. The Japanese Kanban process involves more than fine tuning production and supplier scheduling systems, where inventories are minimized by supplying these when needed in production and work in progress in closely monitored. It also encourages; Industrial re-engineering, such as a 'module and cellular production' system, and, Japanese human resources management, where team members are responsible for specific work elements and employees are encouraged to effectively participate in continuously improving Kanban processes within the Kaizen concept (Stainer, 1995: 11).

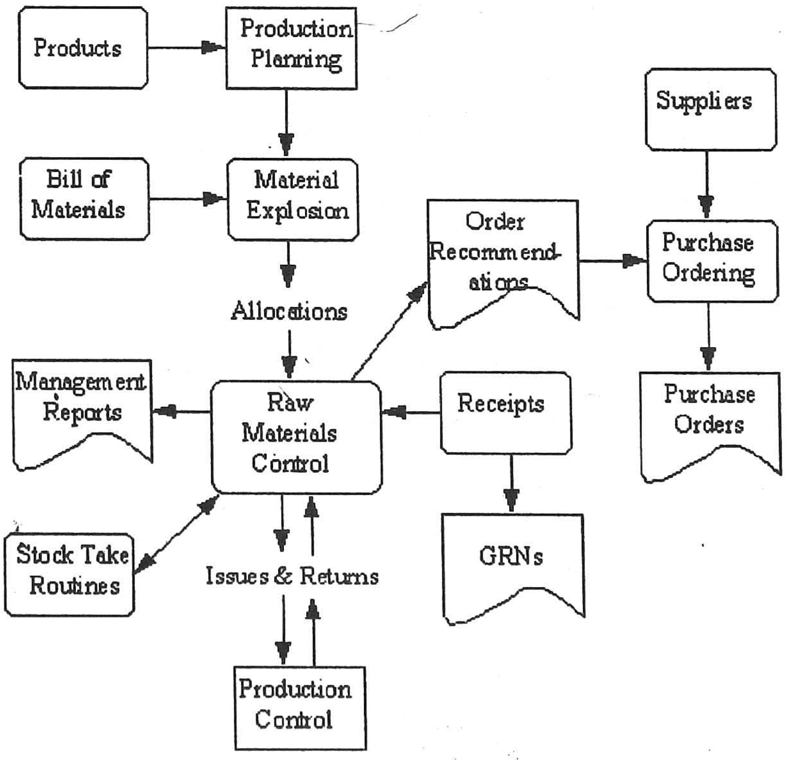
For Example, In the case of many manufacturing plants, the supplier is the warehouse and the customer is the assembly line. In this case, one box of components goes to the correct station at the assembly line at a time. When the box is empty, an operator takes it back to the warehouse, and this automatically triggers the delivery of the next box of components. Since only the transport Kanban is used, this example represents the application of the simple Kanban system. Toyota of Japan has taken the example discussed above one step further. Here, certain components are directly supplied from suppliers to the production line. Stock levels are therefore kept low and factory overhead can be reduced. The supplier's work stations are regulated by the production Kanban, which in turn is regulated by the transportation Kanban from Toyota's production lines. The transport Kanban is simultaneously used internally between the warehouse and the production lines. This is an excellent example of the integrated Kanban system.

10.3.2 ADVANTAGE OF THE KANBAN PROCESS

Roos (1992: 115) notes the following advantages of Kanban over the traditional push system:

- A simple and understandable process
- Provides quick and precise information
- Low costs associated with the transfer of information
- Provides quick response to changes
- Limit of over-capacity in processes
- Avoids overproduction
- It's minimizing waste
- Control can be maintained
- Delegates responsibility to line workers

He further indicates that "Kanban represents an efficient tool to continuously rationalize the production process and find the source of problems" (Roos (1992: 115). Since the circulation of Kanban will stop if there is a production problem on line, it is easy to both spot and correct the problem instantaneously.



MATERIAL REQUIREMENTS PLANNING

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Check Your Progress

1. Explain the KANBAN process.
2. Summarize the advantages of KANBAN Process.

10.4 SUMMARY

MRP II uses a set of computer supported planning and scheduling tools to control production, cash flow, labour, capacity utilization, material purchase and inventory level. MRP II is a logical extension that goes beyond the computations for material requirements. It aims at addressing the entire manufacturing function rather than just a single task within that function. This is very significant improvement in terms of integration that has been achieved by the use of Information Technology. The "Gozinto" philosophy gives the matrix method of describing the relationship between the end product explosion and their subassemblies as well as with the individual components that make up the final product. This philosophy describes the 'goes-into' relationship of components into end products to obtain the bill of materials.

JIT, is a management philosophy aimed at eliminating manufacturing wastes by producing only the right amount and combination of parts at the right place at the right time. This is based on the fact that wastes result from any activity that adds cost without adding value to the product, such as transferring of inventories from one place to another or even the mere act of storing them. For many Japanese companies the heart of this process is the Kanban, a Japanese term for "visual record", which directly or indirectly drives much of the manufacturing organization. It was originally developed at Toyota in the 1950s as a way of managing material flow on the assembly line. Over the past three decades the Kanban process, which Bernstein (1984: 48) identifies as "a highly efficient and effective factory production system", has developed into an optimum manufacturing environment leading to global competitiveness. The Japanese refer to Kanban as a simple parts-movement system that depends on cards and boxes/containers to take parts from one work station to another on a production line. Kanban stands for Kan- card, Ban- signal. The essence of the Kanban concept is that a supplier or the warehouse should only deliver components to the production line as and when they are needed, so that there is no storage in the production area.

10.5 ANSWERS TO "CHECK YOUR PROGRESS"

1. some of the objectives of MRP II are:-

   1. To determines the inventory level of materials in each and every operation, so that the inventory cost can be reduced.
   2. To identify the material quantities, timing when it's needed, avail-

abilities and procurement of the required material for avoiding delays in production and delivery lead time.

3. To improve customer service by meeting delivery schedules promised and forecast the demand for required products.
4. To increase the efficiency of production system by coordinating various operations without any interruption in their flow of materials.

2. The MRP II or Manufacturing Resource Planning has different functions, namely

   a) Business planning

   b) Production planning

   c) Master production scheduling

   d) Materials requirement planning

   e) Capacity requirement planning

   f) Ordering system

3. Just-In-time or JIT, is a management philosophy aimed at eliminating manufacturing wastes by producing only the right amount and combination of parts at the right place at the right time. This is based on the fact that wastes result from any activity that adds cost without adding value to the product, such as transferring of inventories from one place to another or even the mere act of storing them.

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4. Japanese are good at manufacturing. Just ask any global producers of automobiles, copiers, or personal electronics what happened in the 1980s. They will probably tell you how the Japanese captured a large share of

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5. Some of the advantages of KANBAN are:-

A simple and understandable process

Provides quick and precise information

Low costs associated with the transfer of information

Provides quick response to changes

Limit of over-capacity in processes

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Avoids overproduction

It's minimizing waste

Control can be maintained

Delegates responsibility to line workers

CASE STUDY

Material management in the shipyard industry has aroused considerable interest in recent years. It has been emphasized that the effective handling, storage, and flow of materials determine the successful operation of a warehouse. Production, planning, and scheduling are also important and vital in determining shop floor schedules because they minimize processing cost and material inventory cost. There is a need for proper planning and control of processes and materials, including procurement, storage, and inventory, making the process cost effective. Monitoring and tracking in the industry are thus very important in fulfilling the aforementioned objectives. Group technology also plays an important role in material management for grouping and coding. It has been reported that proper grouping and coding of materials not only reduce labour and material handling, but also reduce time and the shifting of parts to different places. This paper addresses several aspects of material management that need to be considered for efficient material handling and inventory management processes. The various aspects of material management, including material handling, inventory management, planning and scheduling, procurement and receiving, monitoring and tracking, controlling, and stat using are highlighted. It should, however, be mentioned that these facets of material management may overlap, and should not be considered in isolation. For best results, the interactions of different facets should be considered in controlling the overall economy of the industry. Recent trends of material management are also summarized. An effort has been made in this perspective to visualize the state-of-the-art in material management with special emphasis on the shipbuilding industry. Several new techniques and trends have been reported for a more efficient and cost-effective material management. These new techniques have great potential for implementation in the shipbuilding industries and need to be explored in relation to greater competition in the global market.

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10.6 FURTHER READING

- R. J. Schonberger, (1996) "World Class Manufacturing: The Next Decade", New York: Free Press.
- W. Skinner, (1996) "Manufacturing Strategy on the S-Curve", production and Operations Management, Vol. 5 (1), pp. 59-77.
- A. S. Lawrence, (1993) "Productivity measurement and improvement", Virginia: Reston.